HEATING AND VENTILATING

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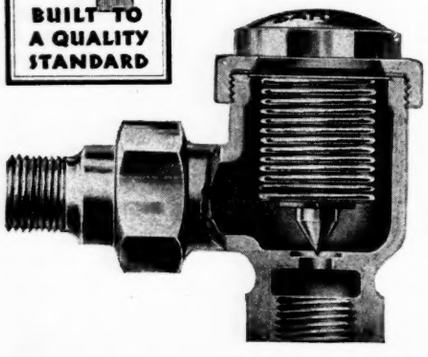

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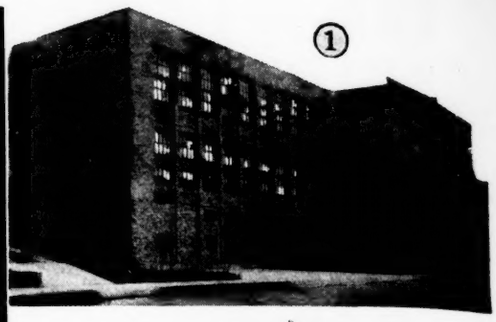

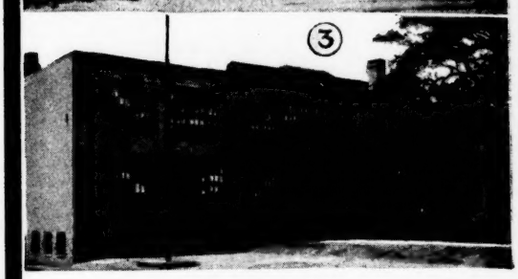

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EDITORIAL

Air Conditioning— Or What Have You

AIR conditioning—a term on whose exact meaning no two people seem able to agree. Vague, new, too all-inclusive in its connotation to be accurately defined in a way satisfactory to all. Since words are the basis of thoughts it follows that razor-keen thinking can take place only where definitions are clear and sharp. Meaning "all things to all men" it is not surprising that confusion exists as to limitations in its meaning and that much misinformation is present in the minds of non-technical and even technical people as to just what it's all about.

In the light of a mere word combination the term may be highly descriptive, but that is not the important point. Of most importance is not even the technical definition which may be placed upon it, but rather the meaning it is to ultimately take in the popular mind. No general and widespread acceptance of the term can be interpreted in any other way. Just what connotation the term will finally take on in the minds of the people remains to be seen. At present it seems to be in the stage where the man in the street likes to roll it off his tongue. Its easy use indicates present moment sophistication, the latest thing in popular catchwords. But the final crystallized meaning is not yet apparent.

As is usual with popular catch phrases, everyone is willing to make use of it. Every conceivable kind of scheme and apparatus varying all the way from simple teakettles to elaborate and highly complicated and automatic devices are offered to a long-suffering and probably somewhat puzzled public as being "air conditioning." Just that. Nothing more or less. Nor is any one willing to admit for a moment that his application does not represent the last word. Does his device cool air, then cooling in his presentation is the only factor of any importance in the popular air conditioning. Does it add moisture to the air, and do nothing else, then he, too, claims to have fully adequate air conditioning. No matter what it does to the air it is air conditioning.

It is possible that in spite of the present confusion a sharp distinction and a clear-cut definition may finally evolve, but this is open to serious question. It seems more likely that the confusion will eventually either destroy the term entirely, or else that it will be realized that it is too sweeping and must be limited more sharply if it is to be of any descriptive value for accurate thinking.

School Ventilation Legislation in New York

STATE Senator Mastick's bill to amend the New York education law by substituting a provision to read "for assuring proper ventilation" instead of "for assuring at least thirty cubic feet of pure air every minute per pupil" was suddenly reported out of committee and passed by both houses, but was vetoed by Governor Roosevelt. As we go to press a statement of the reasons given for the veto are not available. Thus, this latest attempt to amend the existing act is blocked for the present at least.

It is undoubtedly true that powerful and influential interests were backing the amendment as attested by their ability to obtain its passage through both houses. It also seems likely that this attempt will not be the last.

One of the strong arguments against the amendment was that the time was inopportune in view of the anticipated report of a committee which would make definite recommendations as to suitable ventilation standards for school buildings. It is evident that this argument will lose much of its weight unless the report is available by the time the next attempt at amendment is made. As another move is almost certain at the next session the report and recommendations should appear shortly.

It is certainly to be hoped that when the recommendations are made they may be both convincing and fair. Moreover, the recommendations might very well take into account the several viewpoints on the subject. It is almost too much to expect that any report can actually succeed in reconciling all the interested parties. The engineers have been openly accused of being partisans more interested in promoting the installation of apparatus than in its results. The committee in drafting its recommendations has an opportunity to either disprove this charge or else to show so convincingly that the advocated apparatus is really necessary that all parties will be willing to accept its findings. It is an exceptionally difficult task.

The Theory of Radiant Heating

INCREASING attention is being paid by engineers to the possibilities in radiant heating as being applied to buildings in Great Britain, and more recently to a few installations in this country. The author of this article has pioneered in the work carried on in England, and has been associated with such notable projects as that in the Liverpool Cathedral. Mr. Adlam here deals with the physics of radiant heating, using some particularly interesting analogies.

by

T. Napier Adlam*

THE object of heating is obviously to make the room comfortable. If we cannot with certainty lay down what physical conditions will give comfort in a room, is it not obvious that the whole scientific basis of heat engineering is in doubt? What will future generations think of our present efforts to deal with the physiological side of heating? They will certainly form an opinion that we knew nothing of either physiology or hygiene. It is with the knowledge of our failures in giving to mankind what it is asking of us that we should review our position and, if possible, arrest our inefficient waywardness and make sure we are marching toward the goal of economic and hygienic heating.

After making a very careful study of the progress that has been made, I think that the physiological aspect of the problem has received more scientific attention in England than anywhere else, and I will endeavor to place before you as clearly as possible the latest systems which have been developed in that country to solve the very important problem of determining correct methods of heating. I will, at the same time, give you the relations between the two countries as to their applications, with the results I have obtained so far in my investigations.

PHYSIOLOGICAL ASPECT OF HEATING

It is impossible for anyone to study the best means of applying artificial heat without first considering the physiological aspect of the problem. In fact, without this knowledge it would be impossible for us to appreciate the objects of the various systems which I shall explain later.

In the first instance, we have to realize that our bodies do not require to be kept warm from without, for nature has ordained methods which enable us to be kept warm from within. By metabolism, heat is generated by chemical and physical processes within the body. As we take nutriment into our bodies, the compounds are broken up and oxidized, so that the cells of the body are rebuilt and heat is generated. This process of heat generation takes place in the muscles and also to some extent in the liver and other glandular organs where heat is produced by muscular contraction.

Sufficient heat is generated to keep our bodies at a normal temperature just above 98° F. and the surplus heat is given off in various ways. Assuming an ordinary healthy person at rest or in a sedentary occupation, we find the losses from the body to take place approximately in the following proportions:

Radiation and convection	72%
Evaporation from the skin	15%
Respiration	11%
Excreta	2%

These figures are approximate, for we know the amount of heat generated by metabolism varies with age, food, environment and other conditions. Age affects the total heat to a considerable extent.

The total amount of heat which the average person gives off when at rest and not eating is about 410 B.t.u. per hr. For the purpose of our thesis we are directly concerned only with the heat given off by radiation, convection and evaporation.

It is vitally important, however, that the amount of this heat—and more especially the different ways in which our bodies give it off—should be clearly understood. Every heating engineer or architect who designs a heating system should give due regard to this physiological aspect, and forget the old idea that a heating system is installed to heat the building, for we shall see presently that the idea of thermometrically designating the conditions for comfort is crude and erroneous.

A heating system should give conditions suitable to the actual requirements of the human body, and not be merely an arrangement to warm the building.

We have seen that approximately 72% of 410 B.t.u., or 295 B.t.u., are given off from the body per hour as radiant and convected heat, although it is difficult to differentiate the exact proportion. It has been found that a comfortable condition results if the surroundings are such that the body gives off about 200 B.t.u. per hr. as radiation and the remainder as convection.

We have here a very complicated process and one which is extremely difficult to understand, for actually the feeling of hot and cold in an individual is not necessarily a measure of the rate of heat loss from the body

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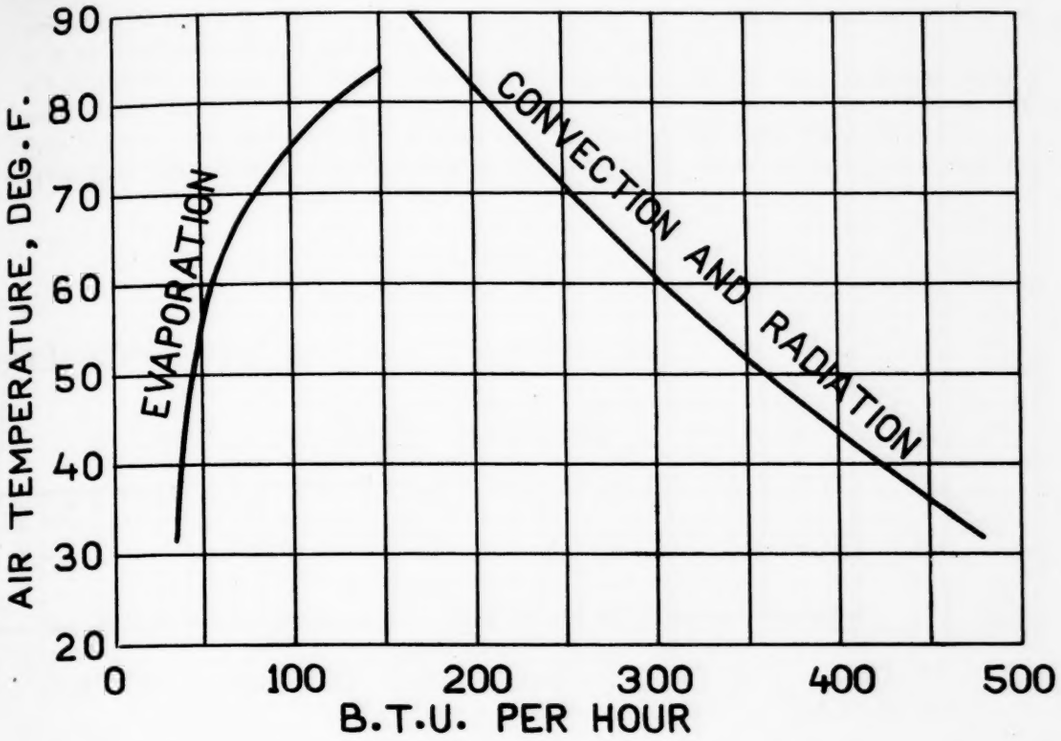


Fig. 1. Effect of Air Temperature on Heat Dissipated from Human Beings

compared with the heat generated inside. It is merely that the sensation of the body is more susceptible to the way in which the heat is abstracted from the body.

Broadly speaking, the sensation of feeling cold can be avoided in two ways—first, by raising the temperature of the air surrounding the body to a sufficiently high point, and secondly, by allowing thermal radiations from a warm object to impinge on the body with sufficient intensity to make up for a lower air temperature.

These are the two methods we must analyze to ascertain how closely they meet the requirements of nature, and then we can determine what means are necessary or available, to create the conditions which give the greatest degree of comfort.

If first we assume that we keep the body warm by heating the surrounding air, then we find we have to heat this air to a comparatively high temperature so that it will raise the temperature of the walls, ceilings, etc., to a point that will check the rapid loss by radiation from our bodies. This is important for we shall see presently that the loss by radiation from a warm body to a cool body is proportional to the fourth power of the respective temperatures, regardless of the temperature of the air surrounding us.

Now, in the case of warming a room by heating the air, or shall we say convected heat, we find that the surface temperatures of the walls are about 4° colder than the air temperature, so that to raise these surfaces to a suitable temperature we have to have a high air temperature. What we actually do is to raise the air temperature so high that we stifle the loss from our body by convection, and allow it to give off proportionately more by radiation or by evaporation. This may balance the total account, but it is altering the true course of nature. We will, however, refer to these actual conditions after we have examined the physiological aspect further.

The humidity largely affects this question, as we shall see later, but not to the same extent as radiation.

Undefinable feeling of stuffiness and lassitude does not refer especially to high surface temperature heating only, but is common to all convected-heat methods of warming. It is mainly due to the entire lack of energy for, as we shall see later, warm air contains little radiant energy and is therefore unable to compensate for the loss of energy which is taking place from our bodies to the surrounding cold objects.

We have already seen that under standard conditions nature demands that the body shall give off only a definite quantity of heat, and also that she has her own way in which this shall be given off. If we raise the temperature of the air too high we crowd up on our body an abnormal amount of heat which nature tries to dissipate, but as the conditions are not satisfactory to the true process of metabolism, it becomes unbalanced, our muscles become relaxed, to prevent generating heat, and all nature within us calls for a general relaxation. In other words we feel a lack of energy, simply because we cannot dissipate the heat in the correct way to meet the physiological functions of our body.

Fig. 1 shows the effect the air has on the heat dissipated from our bodies and it will be readily appreciated to what extent a higher air temperature does upset the balance of heat losses. From this chart an air temperature of 60° appears to give us the correct air temperature for heat losses, but this, however, depends on the relative humidity of the air as well as the temperature.

Assume, on the other hand, that we are keeping the body warm with thermal radiations, and here we come to conditions somewhat of the manner which nature herself ordained. Not only can we keep ourselves warm by subjecting our bodies to thermal radiations with greater economy, but we do so in a way which assists nature in

her wonderful machinery by which the temperature of the body is controlled.

To substantiate this, we have evidence in the great cure that is being effected on invalids who lie about in Switzerland, and other places, with only scanty clothing although the air is extremely cold. The cold air stimulates the muscles and organs of the body, and the rays coming direct from the sun and reflected from the ice and snow, keep the body warm and healthy. The invalids are kept warm entirely by the rays of energy impinging on their bodies, and it is beyond doubt that the energy given to the body acts as a tonic.

Certainly the rays in this instance consist of the whole series through infra-red to ultra-violet, but the infra-red rays give the greatest heat to the body, and allow the person to live in comfort, while breathing cool and untreated air.

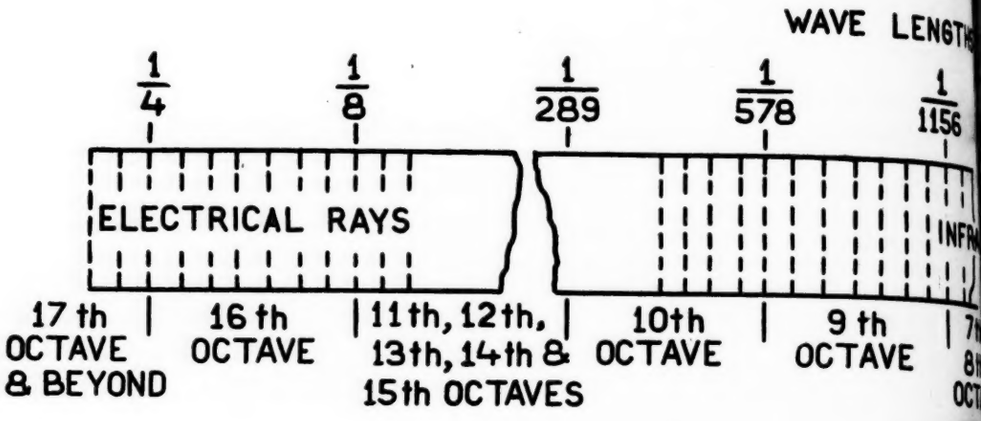
There is no doubt that radiant heat means radiant energy, although with low temperature radiation we cannot obtain all the advantages which the sun gives us, and I do not suggest that radiant heat is the answer for all heating problems. Radiant heat waves, however, are the only means by which heat is sent to us from our central supply, and without doubt this is the way in which it should be applied artificially to assist nature in controlling the temperature of the body.

HUMIDITY

In considering the physiological aspect of keeping warm we must not neglect the humidity of the air, for this is also a very vital factor and it plays a very important part in producing health and comfort.

When water evaporates it must abstract the latent heat of evaporization from somewhere, so that any moist object becomes cooler as it begins to dry and the moisture evaporates. This is what happens to our bodies. Under ideal conditions we should evaporate sufficient to give off 61 B.t.u. per hr. and by evaporation at this rate we cool the surface of our bodies down to the required temperature demanded by nature.

Assume that we are in a room with an air temperature of 70° F. (I have taken this temperature, as it is the usual temperature asked for in this country at the present time) and a humidity of 30%. If under these conditions we have a wet bulb thermometer we shall find that the temperature recorded by this instrument



is 16° lower than the dry bulb temperature, viz. 54°. Now, as we have moisture in our skin which is being evaporated continually, the surface of our skin tends to fall to this low temperature. Under our skin we have a layer of fat which is kept at a normal temperature of 92° and any rapid cooling of the skin surface means a greater transmission of heat from this layer of fat, and it is when this transmission is abnormal that we experience a chilly feeling.

If, instead of a 30% relative humidity, we add moisture and raise the relative humidity to say 60% then the lowest temperature to which the skin would tend to fall would be 61°. This would make a marked difference on our feeling of comfort. I know that this high degree of humidity would produce a deposit of moisture or crystalline deposit of frost on the windows, but in England the former is dealt with by having a small hole, or several holes made through the wood or stone sill to the outside. The deposited moisture is largely influenced by the outside temperature, and in milder weather it is not so noticeable.

The question is what degree of humidity do we need to meet our physiological requirements? The question has already been considered in this country and a trial made by raising the humidity from 30% to 40%, but neither of these figures meets the needs, and without doubt these investigations were made without taking into consideration the effect of radiation and convection. On an invigorating spring day we find that 60% relative humidity is the ideal condition, and even up to 65% and 70% if the air temperature is below 60°.

It has been computed that the minimum death rate occurs in localities where the natural relative humidity is maintained at a fairly high figure and an average

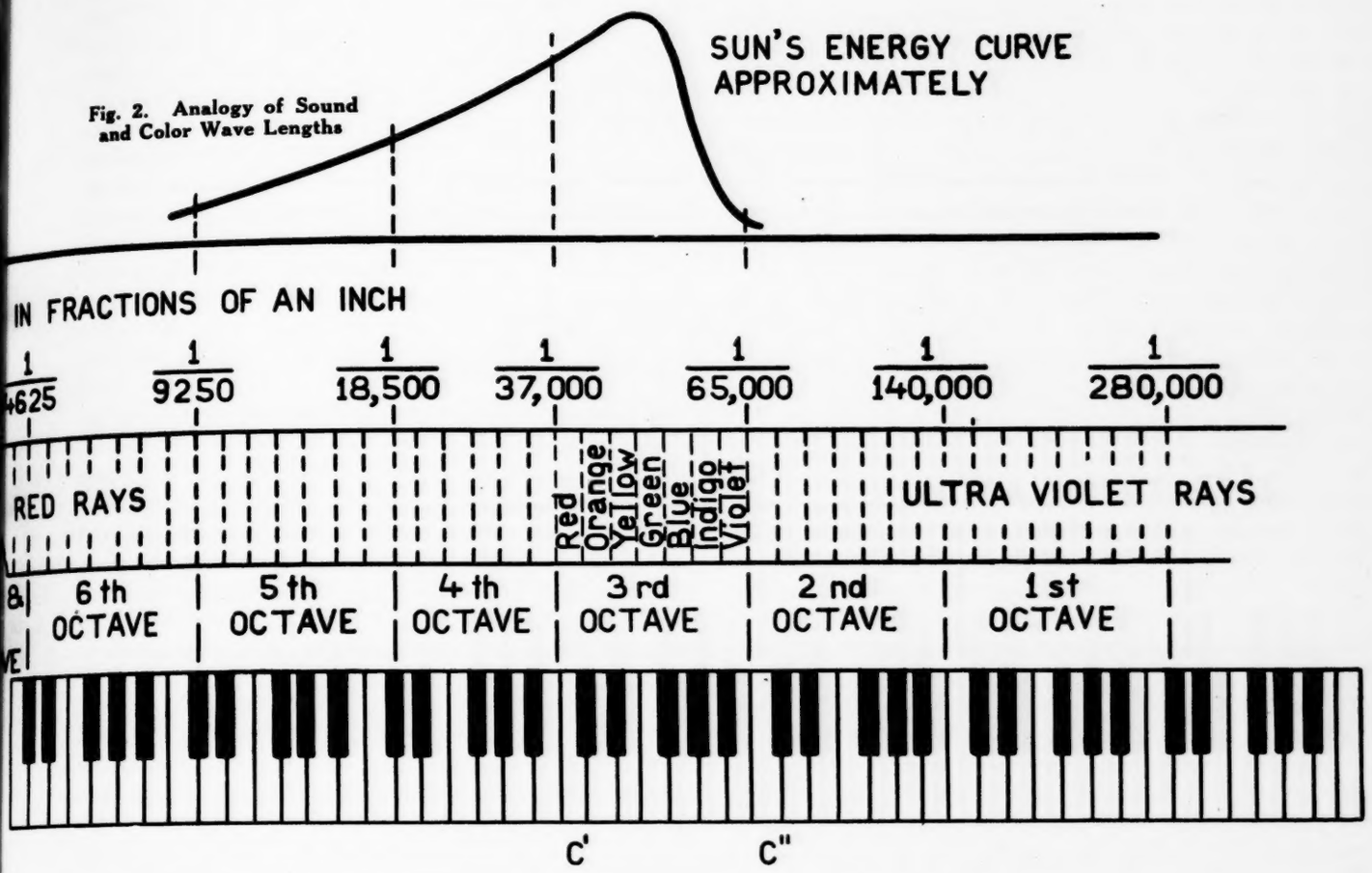


Fig. 2. Analogy of Sound and Color Wave Lengths

daytime humidity of 60% seems to be compatible with the physiological requirements of our body.

From experiments I have made in this country I find that after taking into consideration the moisture effect on the windows and applying radiant heat, I get a very comfortable condition with an air temperature of 62° to 65° and a humidity of 45% to 55%. A slightly higher humidity gives a more mellow effect, but there is more difficulty with the moisture on the windows in very cold weather.

It will be seen that with an air temperature of 65% and a humidity of 55% the lowest temperature possible by evaporation is 56°—a higher temperature than we obtain with an air temperature of 70° F. and a relative humidity of 30%.

Having studied the physiological aspect of our problem and the most suitable air conditions, we have now to become acquainted with the method by which heat in the form of radiant energy can be transmitted from the source of supply to our bodies.

THERMAL RADIATIONS

Everyone is familiar with the fact that when the surface of a body is illuminated for some time by rays of sunlight, the temperature of that body is raised. In other words, it becomes warmer, due to the heat energy from the sun being absorbed by the surface of the body.

It is also common knowledge that the condition of the surface plays an important part in relation to its rise of temperature. For instance, we know that an object with a white smooth surface does not become so hot as one with a dull black surface, hence roofs and skylights of buildings are often painted white or lime washed. For the same reason people in very hot climates invariably wear white coverings instead of dark.

We can readily see that taking several objects, each with unit area of surface, and exposing them to the same source of thermal radiations (say from the sun) if one becomes warmer than the others it is because it has absorbed more of the heat rays; but as all have received an equal number of rays in unit time, it is obvious that those rays not absorbed have been reflected. This means that a surface which absorbs heat readily reflects it badly, and that a surface which does not absorb heat readily, must be a good reflector.

We know, therefore, that different surfaces have the power to absorb or reflect thermal radiations depending on the color and condition of the surface. From this we know that any surface will emit heat in the same proportion as it will absorb heat. In other words, the factor of heat emission is equal to the factor of heat absorption.

One other thing we should know about heat rays is that they are reflected from a surface in exactly the same manner as light rays. Thus, we can obtain a strong parallel stream of heat rays from a parabolic reflector when a hot element is placed at the focus. This property enables us to reflect a stream of heat rays from one direction to another, as we would a beam of light when we use a mirror or other reflecting surface.

Very little is known as to the exact nature of radiant heat, but it is commonly assumed to be a form of energy.

Moreover, its vehicle of travel from place to place is not definitely known. Among the explanations advanced is the one that radiant heat is a wave motion in the ether. When these wave motions strike a solid body, molecular vibrations are assumed to be set up and some of the energy of the waves becomes heat in the solid body. When the human body is the recipient the heat deposited on the surface affects the nerves and the sensation of heat results. While the vehicle of transport is not known, it is well established that the direction of travel of radiant energy is always in sensibly straight lines, and that it always moves at a fixed speed of about 186,000 miles per second.

To obtain perhaps a clearer idea of these waves, imagine the effect of throwing a stone in a pool of water. Ripple after ripple spreads out from the center and follows each other over the whole face of the water, or, take a rope and having tied one end to a wall, give the other end a jerk, immediately we see a wave or series of waves pass from one end of the rope to the other. The waves travel but the rope does not, neither does the water in the first example. These are merely tangible examples of wave motion, and the difference between this method of transportation and that of actual displacement of the molecules, such as we get when air or water is heated and moves bodily from one place to another, is obvious.

We can see, therefore, that air convected heat can travel only at the same rate as that of the air which carries it, and the course of the heat depends entirely on that of the air, which is subject to relative weights, pressure and velocity, whereas radiant heat travels at a definite speed, regardless of air currents and temperatures. It can be made to impinge upon any object desired by placing the emitting surface at the correct angle so as to throw the rays in the direction required.

We must at this point consider the relation between the more commonly known long and short wave lengths.

We are all familiar with the spectrum of colors which we obtain when we pass a narrow beam of light through a glass prism. There we get the seven colors divided in the same definite order as we see them in the rainbow —red, orange, yellow, green, blue, indigo and violet. This range of colors constitutes what is commonly known as the visible part of the spectrum, because the nerves of our eyes are sensitive only to wave lengths over this range.

The wave lengths vary through this range of colors from 1/65,000 in. for the violet, to 1/37,000 in. for the red. To realize the speed at which the vibrations take place we have to imagine a figure like 500 billion, for this is the number of vibrations per second made by the red rays, while the violet ray makes double this number.

In Fig. 2 the seven colors are indicated in shaded sections with the wave lengths shown. To enable this to be more readily understood the keyboard of an ordinary piano is introduced as an analogy.

It is common knowledge that as we go up the musical scale the higher notes result from more vibrations and shorter wave lengths than the lower notes. Between two corresponding notes, say between C′ and C″ we have an octave, and the higher note has twice as many vibrations as, and half the wave length of, the lower note. So with the rays, from red to violet we call an octave, because the violet rays are about half the wave length of the red rays. As we go up or down the musical keyboard we have shorter and longer sound waves respectively, and our analogy holds good in all respects.

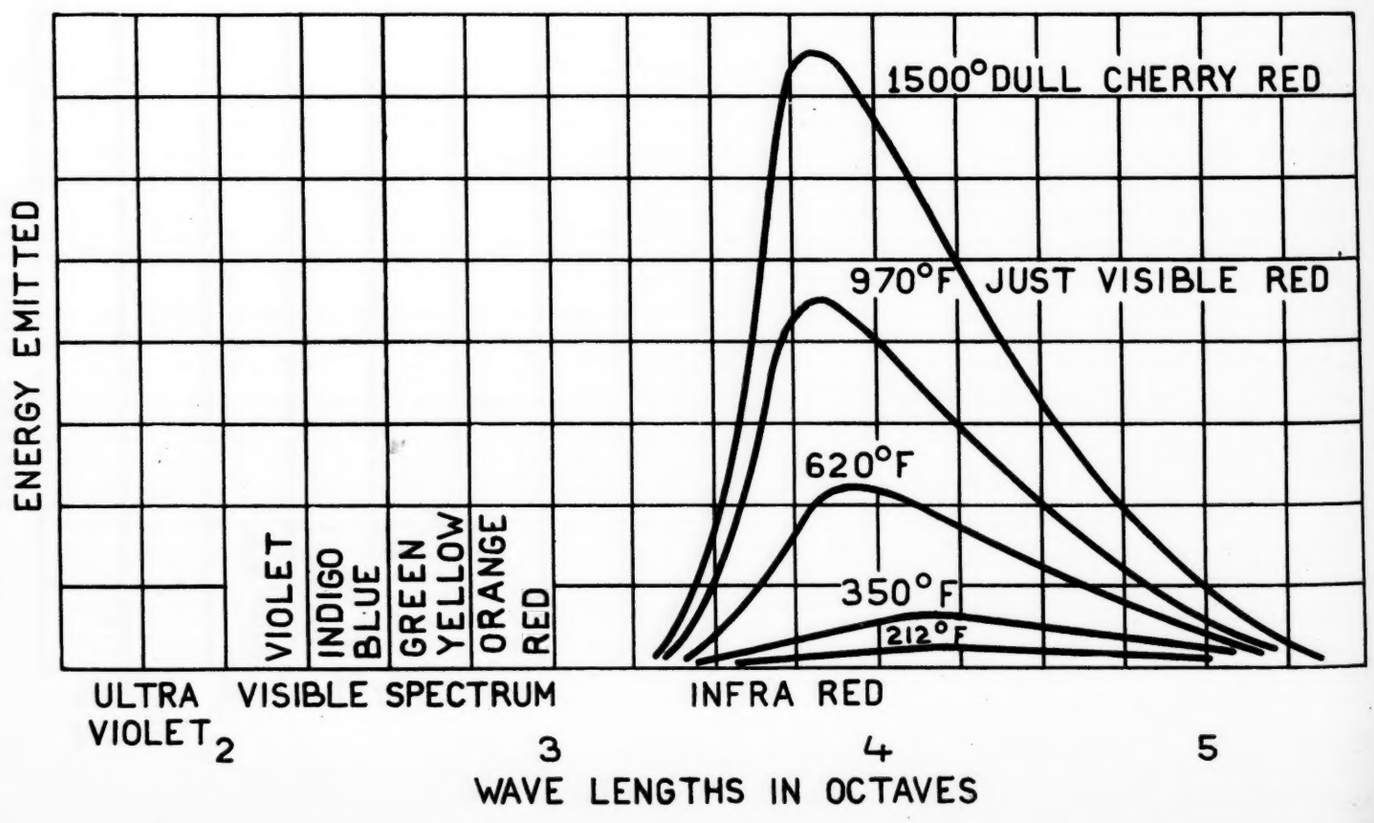


Fig. 3. Rays of Energy Given Off by Blackened Metal

The part of the spectrum keyboard above violet contains rays we cannot see and this section is called the ultra violet, while the part below the red color contains rays too long for us to see and this section is called infra-red. The whole range is divided into octaves, the same as our musical keyboard, but with the difference that the musical keyboard extends only above three octaves below middle C′ because we cannot distinguish a musical note of longer wave length, while the rays in the infra-red portion have been examined down to seven octaves where the wave length is in the region of 1/300 in. long as indicated in Fig. 2. In fact, with the exception of an unexplored gap, the investigation extends into the fifteenth octave and beyond, where we have electrical waves with wave lengths ¼ in. and upwards.

Thus, we have a whole series of waves from ultra-violet at one extreme, through the light producing range, into the infra-red or heat giving rays, and on to the electrical waves. The differences are in the length of the wave and in the properties of the waves which vary considerably.

Now, if we take a piece of blackened metal and raise its temperature we will have rays of energy given off at various temperatures as indicated in Fig. 3. This shows that at a given temperature there is a comparatively wide range of rays given off, and it is the total of these rays which we obtain as radiant heat. As the metal is heated, the wave lengths become smaller and smaller and the energy becomes more intense, until finally even violet light may be emitted.

Fig. 4 shows the relative intensities of energy given off by the sun, electric light and gas light respectively. This is interesting because it will be seen that although we are dealing with sources of heat which are luminous, the maximum points of intensity differ in position of wave length, and also differ in amount. This proves that although we may have luminous heat rays, we do not obtain the solar advantage with artificial high temperature radiations, which is so often claimed. While this high temperature gives a greater intensity it is not comparable to the sun's rays, for while the intensity from the sun is great, the rays travel parallel, and strike evenly everywhere. With an artificial source the rays of luminous heat are divergent because the area of the heat source is small compared with the distance, and consequently the intensity varies inversely as the square of the distance of the body from the source, so that one part of our body may be too hot and the rest too cold.

If we have a surface of such dimensions that the area is large compared with the distance, the rays are then very much less divergent, and can be made practically parallel.

Having studied the nature of these heat rays and their relation to other rays, we can consider the effect of such rays when impinging upon our bodies. We all know how we experience a cool feeling as a cloud passes over the sun. This is a simple demonstration that the heat rays from the sun are shut off simultaneously with the light rays, and another proof that heat rays travel in straight lines and at the same speed as light rays.

If we observe a shielded thermometer indicating air temperature, we find that while the cloud is over the sun there is no reduction in temperature registered by the thermometer for this short period. This leads us to a very interesting and vital point, for it demonstrates that the thermometer is not a reliable instrument for recording a condition of comfort. If we resort to a wet bulb thermometer we are in no better position, for this would

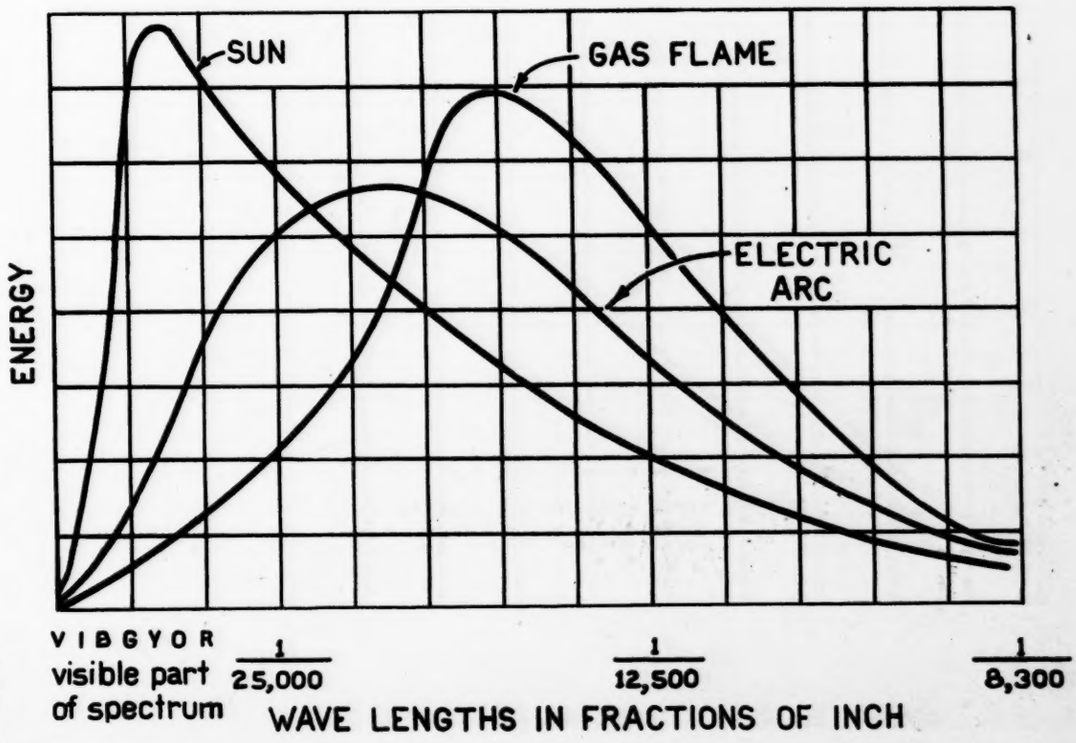


Fig. 4. Relative Intensities of Energy Given Off by Sun, Electric Light and Gas Light

also fail to indicate any such change in a condition that we know makes a vast amount of difference in our bodily comfort.

In the open air on a cold sunny day, with the ground thickly covered with snow, and with the thermometer near the freezing point we may feel a lovely glow of warmth. The reason is that the snow reflects 70% of the energy received from the sun, and this is reflected back to our bodies at all angles, depending on the contour of the snow surfaces. Here we have an almost perfect example of what reflected heat will do, and it leads to the conclusion that we should have good reflecting surfaces on the walls of heated rooms.

The question of absorption by the air is also very important, and we find that within certain limits the greater the area of our source of heat and the smaller the temperature difference between it and the surrounding air, the greater will be the heat absorption by the air. This holds good only for certain wave lengths, and is only applicable for temperatures up to about 200° F. Above that we find that a slight increase in temperatures gives a slight advantage to radiation. We find that rays of short wave length will travel through the atmosphere with practically no loss but the longer waves which are reflected from the earth are practically all absorbed in the moist atmosphere.

Hence we find that, although moist air will absorb long length rays at a rate over 70 times that of dry air, the shorter waves are not absorbed. The sun sends all the rays through the atmosphere unchanged and all the energy reaches us, but the moist atmosphere around the earth arrests all the reflected rays on their return journey.

We also find that short rays from the sun pass through glass without any perceptible increase in temperature in the glass, showing that there is very little absorption, but longer radiation waves emitted from a red fire are largely absorbed by glass.

Consequently, windows will allow the short rays from the sun to pass freely into the room, but the glass protects the longer rays from going out and being lost from the room. This point is important.

The practical applications of calculations of heat emission from various surfaces will be considered when we deal with the respective systems in use, but there is one fundamental principle concerning radiant heat which we should know. That is that the rate of radiation depends entirely on the difference of temperature of the warm object and the cool object, and follows somewhat the following formula:

$$H = KA \left[\frac{T_2^4}{100} - \frac{T_1^4}{100} \right]$$

for parallel surfaces of large area, where

H = heat interchanged.
K = a constant depending on surfaces and actual temperatures.
A = area.
T_2 = absolute temperature of hot body.
T_1 = absolute temperature of cool body.

In calculating heating surfaces for room warming we cannot use this formula as it is because we have some convectional heat, and this depends on the position in which the heating surfaces are fixed. A vertical surface under some conditions will give off as much as 45% of its heat as convected heat and 55% as thermal radiations.

The Radiant-Heated British Embassy in Washington

Chart for Simplifying Calculation of Forced Air Systems

by **J. Donald Kroeker***

A NUMBER of different methods are in use for proportioning duct systems for forced air heating and ventilation. The majority of them employ, in some stage or other of the calculations involved, formulas or charts giving the rate of pressure loss due to friction, tables of equivalent diameters of rectangular ducts for equal friction, and charts or tables of friction in elbows, either in terms of equivalent length of straight pipe or percentage of velocity head. At any rate, the resistance due to friction in such a system must be determined before the proper blower equipment can be selected.

The alignment chart, Fig. 1, lends itself to use in all the operations enumerated and may also be employed to determine directly the total friction in an air duct and to compute sizes of ducts required to carry different quantities of air with the same rate of friction.

The commonly used friction chart[1] is a graphical representation of the formula $h = \frac{klV^{.857}}{d^{1.286}}$, in which h is loss of motive head due to friction, in inches of equivalent water column; l is length of duct in feet; V is velocity of air in feet per minute; d is diameter of duct in feet, and k is a coefficient depending on the nature of the duct surface.

The relation expressed by this equation is represented for average duct work by scales 3, 4, and 6 and alignment of values on two of the scales will give the remaining one. For round pipe, scale 5 also gives simultaneously the volume of air in cubic feet per minute.

The formula and chart are based on standard air[2]; the value of h is affected by air density and temperature. However, the corrections for density and temperature applicable in conditions encountered in heating and ventilating work are so small as to be entirely negligible.

Scales 7 and 8 give sizes of rectangular ducts having the same frictional resistances at the same capacities as round pipe of sizes intercepted by alignment on scale 6. These scales constitute a very simple graphical representation of information heretofore presented in several pages of tables giving values of d in the formula $d = 1.265 \sqrt[5]{\frac{(ab)^3}{a+b}}$, in which d is the diameter of a round pipe having the same friction for the same capacity as a rectangular duct with sides a and b.

In the usual friction chart, circular equivalents from this formula are often erroneously used with values of air volume to determine rate of friction. The same error may also be committed in the use of this chart. *Circular equivalents of rectangular ducts intercepted on scale* 6 *may not be aligned with air volume, scale* 5, *to obtain rate of friction loss.* These equivalents may be aligned *only* with velocity, scale 4, found by division of duct area in square feet into air volume in cubic feet per minute to intercept scale 3 for values of friction. This will be illustrated later.

Friction loss due to 90° elbows is determined by aligning pipe diameters or widths (scale 9) with throat radii (scale 10) to intercept scale 11, lengths of straight pipe of the same diameter or width having equal friction. While values represented by alignment of these scales are quite accurately in line with experimental ones for ratios of throat radii to diameters lying between 0.3 and 1.5, values beyond these limits are approximate only but likely to be easily within the accuracy of calculations and assumptions in heating and ventilating work.

For elbows forming angles other than 90° multiply the values on scale 11 by the ratio of the angle used to 90°.

Total friction is found on scale 2 by aligning scale 1, on which the total length of duct, including allowance for elbows, is made, and scale 3. This is, of course, a simple multiplication but convenient to have on this sheet and necessary to make it complete.

Another use for this chart is to determine diameters of pipes carrying different capacities at the same rate of friction. Charts commonly used for this purpose[3] are plotted coordinately to solve the first equation in the series $\frac{d_2}{d_1} = \left(\frac{Q_2}{Q_1}\right)^{2/5} = \left(\frac{V_2}{V_1}\right)^2$ in which d is diameter of duct, Q is volume of air, V is velocity, *1* is a subscript denoting the main and *2* is a subscript denoting the branch. In these charts Q_2 is plotted as a percentage of Q_1. These equations are approximations of the more unwieldy relations

$$\frac{d_2}{d_1} = \left(\frac{Q_2}{Q_1}\right)^{13/35} = \left(\frac{V_2}{V_1}\right)^{13/9}$$

These more nearly accurate equations are solved mechanically in the present friction chart by aligning d_1 on scale 6 with Q_1 on scale 5 to intercept scale 3, and aligning this intercept with the required capacity, Q_2, of the branch on scale 5 to read d_2 on scale 6. Velocities in the respective ducts may be read directly on scale 4 during the computation of the branch diameter.

Dealing with rectangular ducts having different capacities but the same rate of friction, *only scales* 3, 4, *and* 6 *may be used, for scale* 5 *applies only to round ducts.* Let a_1, b_1, *and* a_2, b_2 be the dimensions in inches of the main and the branch, respectively. To find the size of the branch two mechanical operations are again required. The circular equivalent of a_1 and b_1 on scale 6

*Heating Engineer, Pennsylvania Furnace and Iron Company.

[1] HEATING AND VENTILATING, *December* 1930, *page* 85.

[2] *Air at* 29.92 *in. of mercury,* 70° *dry bulb temperature and* 50% *relative humidity.*

[3] *"Fan Engineering," 2nd Edition, pp.* 88 *and* 89.

is aligned with velocity on scale 4 obtained by solving

$$\frac{Q_1 \times 144}{a_1 b_1} = V_1$$

to intercept scale 3; then a_2 and b_2 are the dimensions of the duct, the circular equivalent of which aligned with the intercept on scale 3, which was found in the first operation, will intercept a velocity on scale 4 equal to V_2 in the equation $\frac{Q_2 \times 144}{a_2 b_2} = V_2$. The second operation will be illustrated later.

To illustrate the use of this chart a simple example of proportioning a duct system for heating a hypothetical one-story building will be given. Assume registers located as shown to supply the quantities of air indicated in the preliminary sketch, Fig. 2, and that the heating plant is to be located as shown. The main or trunk line is to be proportioned to have the same resistance throughout its length.

A velocity of 600 ft. per min. is chosen for the most remote section of horizontal duct *e* which is to supply 300 c.f.m. The size of this duct will therefore be 8 in. x 9 in. Aligning 8 and 9 on scales 7 and 8 we find the circular equivalent on scale 6. Align this point on scale 6 with the velocity, 600, on scale 4, and it will intercept scale 3 at 0.09. This is the friction per 100 feet and is the rate of friction for which the entire main duct is to be designed.

To find the total friction the type of elbows used is determined. Assume for this example that in all elbows the ratio of the throat radius to the diameter is 0.5. Allowance for elbows is then found by aligning scales 9 and 10 and reading the equivalent length on scale 11. The 9-in. ell entering section *e* thus has a 4.5-in. radius and a 9-in. diameter and will be found equal in friction to 23 ft. of straight duct; the 8-in. ell rising to the

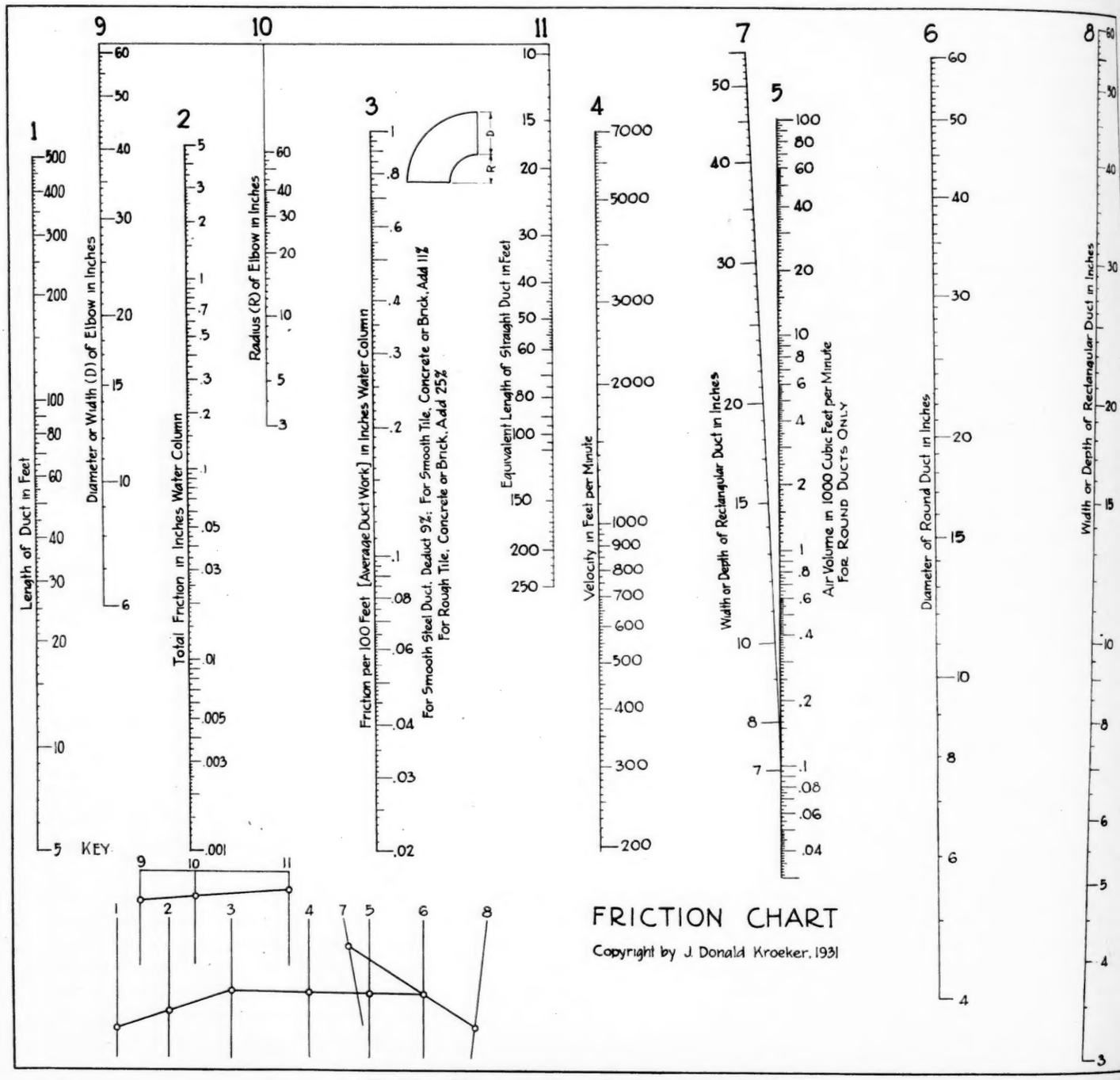

9
10
11
1
2
3
4
7
5
6
8
Length of Duct in Feet
Diameter or Width (D) of Elbow in Inches
Radius (R) of Elbow in Inches
Total Friction in Inches Water Column
Friction per 100 Feet [Average Duct Work] in Inches Water Column
For Smooth Steel Duct, Deduct 9%; For Smooth Tile, Concrete or Brick, Add 11%
For Rough Tile, Concrete or Brick, Add 25%
Equivalent Length of Straight Duct in Feet
Velocity in Feet per Minute
Width or Depth of Rectangular Duct in Inches
Air Volume in 1000 Cubic Feet per Minute
For Round Ducts Only
Diameter of Round Duct in Inches
Width or Depth of Rectangular Duct in Inches
KEY
FRICTION CHART
Copyright by J. Donald Kroeker, 1931

Fig. 1. Alignment Chart for Forced Air Systems

Section	Air volume (cu. ft. per min.)	Equivalent Length* (feet)	Duct Friction (inches)		Velocity (ft. per min.)	Size (inches)
			In Section	Total from starting point		
			WARM AIR SYSTEM			
e	300	12 + 43	0.050	0.050	600	8 × 9
d	700	12	0.010	0.060	740	8 × 17
c	1100	7	0.006	0.066	830	10 × 19
b	1425	5	0.004	0.070	890	10 × 23
a	1825	8 + 7	0.011	0.081	930	10 × 28
f	400	12 + 20	= e; 0.048		800	8 × 9
g	400	12 + 45	= d; 0.055		655	8 × 11
h	325	4 + 45	= c; 0.067		730	8 × 8
i	400	4 + 45	= b; 0.072		790	8 × 9
			COLD AIR SYSTEM			
k	700	30 + 25	0.011	0.01	400	10 × 25
j	1025	37 + 63	0.02	0.03	445	10 × 33
l	800	24 + 55	= k; 0.031		550	10 × 21

*Where two figures are given in this column the first represents the actual length of the duct, the second the sum of the various equivalent lengths for elbows.

Summary of Friction Losses: Warm air ducts, .081; Warm air registers, .004; Cold air ducts, .030; Cold air grilles, .004; Furnaces, .020; Filters, .020; Total, .159.

register, with an $\frac{R}{D} = \frac{4}{8}$ is found in the same manner by aligning scales 9 and 10. On scale 11 we find the equivalent length to be 20 ft. The total equivalent length of this section is therefore 12 (the length of straight duct) + 20 + 23 or 55 ft. which, located on scale 1 and aligned with the rate of friction 0.09 on scale 3, will intercept scale 2 at 0.0495, the total friction in section *e*.

Since the velocities through the free areas of the registers have been selected to be equal (200 ft. per min.) for all warm air outlets and cold air intakes, the friction losses through these openings may be considered independently of the duct systems.

The remainder of the system may now be sized. Section *d* is to be a duct 8 in. deep which will carry 700 c.f.m. with a friction loss of 0.09 in. per 100 ft. of length. Its other dimension is obtained by finding the duct size, the circular equivalent of which aligned with the rate of friction loss fixed, 0.09, will intercept a velocity on scale 4 equal to that found by dividing the air volume by the square feet of duct cross section. Assume an 8 in. x 20 in. duct is to be examined as to its ability to meet the requirements.

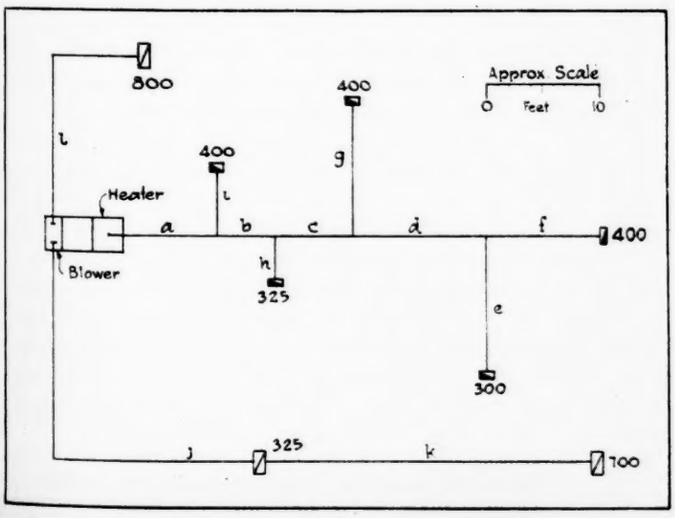


Fig. 2. Layout Used as Typical Problem

The velocity in this duct would be $\frac{700 \times 144}{8 \times 20}$ or 630 ft. per min. Now if the circular equivalent of this duct aligned with 630 on scale 4 intercepts scale 3 at 0.09, the requirement stated will be satisfied and the duct will have the required friction per foot of length. However, the intercept of the circular equivalent of an 8 in. x 20 in. duct aligned with 630 on scale 4 gives a friction of only 0.061 in. per 100 ft. By another trial it is found that an 8 in. x 17 in. duct, in which the air has a velocity of 740 ft. per min. and which has a circular equivalent of 12.7 in. will align with 0.09 on scale 3 so that it is the proper one for this case.

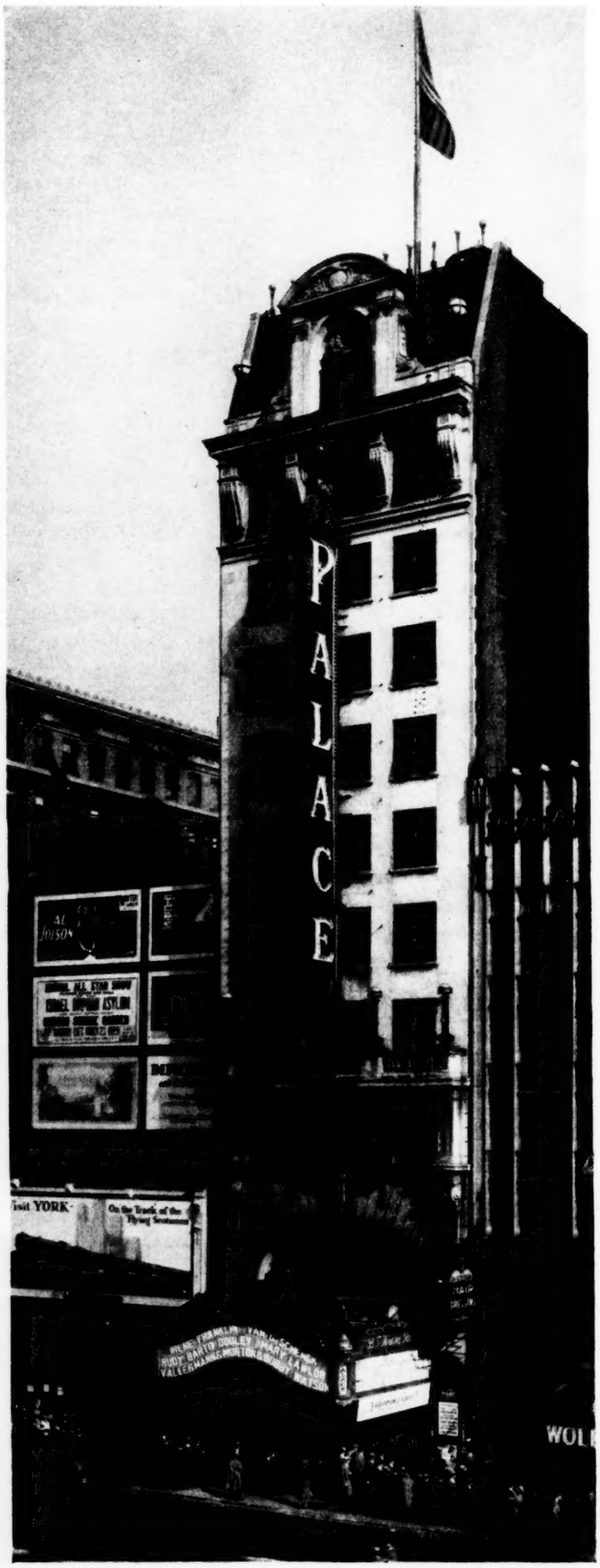
This method is pursued further to determine the size of the remaining sections of the trunk line.

Each branch must have a resistance equal to that in the trunk line up to the point at which the branch takes off. Thus section *g* is designed for an 0.060 in resistance. An allowance of 20 ft. and 25 ft. is made for elbows leaving the trunk and issuing into the register, respectively. The equivalent length, 57 ft., on scale 1 is aligned with the total resistance, 0.060, on scale 2, to intercept scale 3 at 0.115, the rate of friction in this branch. The duct is now sized in the same way as all but the most remote sections of the main or trunk.

In sizing the cold air return line, the velocity in the most remote section, *k*, is chosen, for this example, as 400 ft. per min. The size of this section and the rate of friction in it are determined on the basis of this velocity. This same rate of friction will again apply to the entire trunk line. The remainder of the cold air system is now designed in the same manner as the warm air ducts.

In conclusion, this chart provides for the solution on a single sheet of all the major unwieldy formulas used to compute friction and in sizing pipes or duct systems required to move different quantities of air to scattered points in heating and ventilating work. Being a nomographic alignment chart, it is also simpler and less confusing, and has a greater number of divisions on each scale, making it easier to manipulate than charts plotted coordinately.

Operation of Air Conditioning Plants



WITH the month of May appearing on the calendar, theater owners, having just seen the last of their fuel bills filed for the past winter, know that the next batch of bills to appear regularly each month until it is time to turn the heat on again in the fall, will show a considerable increase in electricity and water used. Moreover, new bills for lubricating oil and refrigerant will appear and one or two new operating engineers will be added to the payroll. At least the owners of more than 300 theaters will be so affected, for that many theaters have already been equipped with air conditioning systems to provide comfort for the theater-going public during the warm months of the year.

A cooled theater is no longer a novelty. The public rather expects it today and will naturally seek out the cool theater always. A few years ago theater cooling plants proved a handsome investment as the first cost was returned, in some cases, in two years or less. It was a novelty then and the public, always eager for something new, swarmed to the cooled theaters.

Gradually with more theaters installing cooling plants the patronage of the public was divided among the various theaters so equipped until it became a case of choosing the best show in the nearest and most comfortable house. As a result owners found that the cost of a cooling plant is just another fixed charge that must be paid off much as the other items are paid.

Naturally, the thousands spent for the plant, varying from $15,000 to $80,000 or more, depending upon variable factors such as size of theater, whether new or old, type or make of plant, location of theater, etc., should prove an investment and should earn a return. The plant should draw rather than repel patronage. In order to do this the plant must not only be well operated but the operating cost must be within reason.

OPERATING COSTS

When purchasing the plant, with first costs in mind running to thousands, as mentioned, the matter of operating cost was secondary—probably it was either minimized or else not brought up at all. If mentioned, the owner was probably told that the operating cost including interest on the investment, depreciation and repairs would be one-half a cent to one cent per patron per day.

Fig. 1. Palace Theater, New York, for which the Author Designed the Air Conditioning System

in Theaters and Auditoriums

by **M. G. Harbula***

This, of course, sounded insignificant and as a matter of fact would be very little to expend for a patron's comfort.

With a 3000-seat house and with each seat filled once a day, this would be a minimum of $15 and a maximum of $30 per day. If each seat is filled twice a day, or if there were 6000 paid admissions for the day, the minimum would be $7.50 and maximum $15 per day. Such figures are rather difficult to reconcile with the facts if the owner were to check up on his electrical and water meters (if he is fortunate enough to be so equipped) at the beginning and at the end of the cooling plant season and add all other bills chargeable to the plant.

The following figures may be enlightening to either the independent or chain theater owner. They represent summaries taken from daily operating logs of a large chain-owned theater in New York. It may be emphasized that this theater is *not* a neighborhood house because of the fact that the daily attendance in neighborhood houses is decidedly less—averaging considerably less than a patron per seat per day, thus raising the cost per patron per day.

TABLE I

Theater seating capacity	3,222
Daily average of patrons	4,452
Patrons per seat per day 4,452 ÷ 3,222	1.381
Cooling plant operating season	104 days
Water consumption as indicated by water meter readings at the beginning and end of the operating season	2,745,570 cu. ft.
Electric consumption as indicated by meter readings at the beginning and end of the operating season	180,180 kw.-hr.
Cost of water at $1.00 per 1,000 cu. ft.	$2,745
Cost of electricity at 3c per kw.-hr.	5,405
Cost of refrigerant (CO_2) (includes initial charge at start of season and make up for balance of season) 180-50# drums @ 8½c per lb.	765
Cost of ice machine and general lubricating oil. 140 qt. @ 35c	48
Cost of two operating engineers at $60. each per week. 15 weeks @ $120	1,800
Total	$10,763
Cost per day $10,763.00 ÷ 104	$103.46
Cost per patron per day $103.46 ÷ 4,452	2.32 cents
Cost per season per seat $10,763.00 ÷ 3,222	$3.34

The above figures show only actual operating costs of the cooling plant in the theater and do not include interest on the investment, depreciation, obsolescence or repair of equipment, nor is the cost of electricity for operation of fans or water circulating pumps included.

This particular cooling plant was one of 18 similar plants in theaters owned or controlled by one corporation and operated under the supervision of the owner's maintenance department.

In many instances the heads of corporations owning chains of theaters and even independent theater owners themselves, know comparatively little or nothing regarding cooling plant operating costs. However, in these days of close competition making it necessary to reduce overhead to a minimum, such owners will no doubt seek ways and means to reduce operating expenses. The figure of approximately $11,000, brought out above, covering the cost of operating one cooling plant, may or may not mean something to an owner.

Consider, however, a corporation owning in its chain 50 cooled houses, which some do today, with seating capacities varying from 1,700 to 3,500 seats or an average of 2,600 seats per house. With the above cost of $3.34 per seat per season the operating cost of one house of 2,600 seats per season would be $8,684 and for 50 theaters, the figure would reach the sum of $434,200 or almost a half million dollars. Capitalized at 6% this would be the interest on approximately seven and one

M. G. Harbula has been specializing in air conditioning work since 1914, and has designed plants for practically every application of air conditioning to manufacturing processes and for all types of public buildings. In 1926 he established a consulting practice in air conditioning.

Mr. Harbula is well qualified to write on theater air conditioning, having designed twenty-six plants, among which are those in the E. F. Albee, Brooklyn; Keith's Memorial, Boston; Palace, Cleveland; Proctor's 86th Street, New York; Palace, New York; Keith's, Dayton; Palace, Cincinnati; and Palace, Columbus.

quarter million dollars. And this amount of money is spent under the supervision of maintenance departments which incidentally are themselves costly as a rule.

There are theater cooling plants that are operated under no supervision whatsoever, the author being familiar with some where costs exceed those mentioned above by as much as 15% to 25%, and conversely, plants in theaters of the same size as detailed hereinbefore have been operated for 25% to 50% less than the $11,000 mentioned—but under proper supervision.

With economy the watchword today, more than ever, a great amount of thought will be given to methods of reducing overhead and the general expense of running a theater. And it may be surprising to realize that of all the expenses of a cooled theater, that of operating the cooling plant itself is perhaps the only one which lends itself to any material reduction. The cost of pictures is determined before they are bought, so also is the cost of a stage show and orchestra; advertising is a known quantity, usually a budget affair; theater help, from the manager to the janitor, has been reduced to a minimum. Lighting costs are readily kept to a minimum due to the fact that it does not require an engineer or expert to determine that when a light is turned on it costs something. Consequently, lights are turned on only when absolutely required for theatrical or show effects or general illumination. With a cooling plant, however, one deals with a seemingly complex science—that of air conditioning,—(usually termed "air cooling" among theater owners) also with the vagaries of the weather and the comfort of thousands of people congregated under one roof for a comparatively short period.

The operation of these plants is left to an engineer who may be under the supervision of the manager, building superintendent, the owner direct if the theater is independently owned, or the home office maintenance department, if a chain-owned theater. At least for the purposes of organization charts or having him know who his "boss" or superior is, he is placed under someone's supervision, but such supervision is often merely superficial, as water or electrical meter readings will testify.

It naturally cannot be any more than superficial because not one of the supervising bodies or persons mentioned has the kind or amount of knowledge or experience necessary to advise, instruct, educate or check the operating engineer of an air conditioning plant. The owner, if an independent, is a showman most of all. The manager, if he attended a manager's school, received some general instruction covering the mechanical equipment of a theater, but it is beyond reason to expect him first, to be a technical man and second, if he is such, to be an air conditioning plant expert qualified to tell his engineer how to operate the cooling plant for maximum economy. Where there is a maintenance department it is usually charged with the maintenance of everything connected with a theater, from plumbing, projection machines, furnishings, organs, stage equipment, heating, ventilating and refrigerating machinery, electrical equipment, etc. It would be prohibited from a standpoint of departmental cost, and in fact really unnecessary, to employ an expert for each of these phases of theater maintenance. Consequently it is not done. Naturally, therefore, maintenance men are "Jacks of all trades" but usually "masters of none."

Certainly maintenance men cannot be expected to know intimately or even generally the variable factors entering into the operating economy of the cooling plant. Even though, as with the larger chains, maintenance departments are provided in some isolated instances with one or two technically trained men whose "charted" duties—among others again—include the supervision of cooling plants, such men are not qualified for the particular work of instructing or supervising cooling plant operating engineers because of their own total lack of knowledge of the science of air conditioning, and a lack of intimate knowledge of all the different elements of equipment constituting an air conditioning plant. As a result very little if any real supervision is given the operating engineer.

This is unfortunate and may cost the owners thousands of dollars every year. On the other hand, he can often very readily save that much in a single summer's operation by providing suitable supervision for the operator. The average engineer is usually willing and ordinarily takes pride in effecting economies in his plant but is handicapped because of lack of proper supervision, knowledge and experience.

When the owner purchased the plant probably he was informed by the contractor that the contract provided for a 10, 15 or 30-day operating period by the contractor after the plant was first placed into operation for the purpose of instructing the owner's engineer. As a matter of fact the contractor's representative who is delegated to instruct the engineer is often an all-around workman, who usually is employed on odd unfinished jobs for the contractor during the period mentioned, unless the owner's representative is diligent in his work to see that contract specifications in regard to the 10 to 30-day operating period are met to the letter. The contractor's man may also use this time to test his plant for maximum guarantees and thus the engineer's instruction, if any, is on the side of waste in utilities, namely, water and electricity.

Instruction cards, simple or elaborate, as the case may be, depending upon the probable advertising value of the plant to the contractor, are sometimes furnished by him, presumably for the operator's guidance. They contain little or nothing in the way of information as to how to operate the plant economically. As a consequence, although when he signed the contract for the plant the owner thought everything was provided for, including the education and instruction of his engineer along the lines of operating economy, he will find upon scrutiny of his electrical, water, refrigerant and lubricating bills that something was and is being neglected. The item lacking is proper, continuous, diligent and, above all, expert and efficient *supervision* of operating engineers and cooling plants by competent technical men of long and varied air conditioning experience.

The following figures show a concrete example of what proper supervision can mean to an owner in effecting savings in cooling plant operating costs. They also represent summaries taken from daily operating logs

of the same New York theater mentioned hereinbefore but for the year previous.

TABLE II

Theater seating capacity	3,222
Average daily number of patrons	4,565
Patrons per seat per day 4,565 ÷ 3,222	1.417
Cooling plant operating season	100 days
Water consumption as indicated by water meter readings at the beginning and end of the operating season	1,925,970 cu. ft.
Electric consumption as indicated by meter readings at the beginning and end of the operating season	122,490 kw.-hr.
Cost of water @ $1.00 per 1000 cu. ft.	$1,926
Cost of electricity @ 3c per kw.-hr.	3,675
Cost of refrigerant (CO_2) (includes initial charge at start of season and make up for balance of season) 133-50# drums @ 8½c per lb.	565
Cost of ice machine and general lubricating oil, 90 qt. @ 35c	32
Cost of one operating engineer 15 weeks @ $60.00	900
Overtime for engineer	130
Total operating cost for season	$7,228
Cost per day $7,228.00 ÷ 100	$72.28
Cost per patron per day 72.28 ÷ 4565	1.58 cents
Cost per season per seat $7228.00 ÷ 3222	$2.24

Simple subtraction will show at a glance the savings effected by constant, proper expert supervision:

Operating cost for season with owner's supervision	$10,763
Operating cost for season with purchased supervision	7,228
Savings effected by purchased supervision	$3,535

Operating season—average of two years 102 days—saving per day—$3535.00 ÷ 102 = $34.65 per day or $242.55 per week.

•

The above savings as noted are in connection with one theater for one season. Consider again the chain owning 50 cooled houses with average seating capacity of 2,600 seats:

Operating cost per seat per season — owner's supervision $3.34
Operating cost per seat per season — purchased supervision $2.24
Operating cost per theater per season — owner supervision
$3.34 x 2600 seats = $8,684
$8684 x 50 theaters = $434,200, total operating cost.
Operating cost per theater per season—purchased supervision
$2.24 x 2600 seats = $5,824
$5824 x 50 theaters = $29,200
Savings in one season for one theater = $2860
Savings in one season for 50 theaters = $143,000

The operating savings effected by purchased supervision, namely $3535 noted above, in slightly over 3

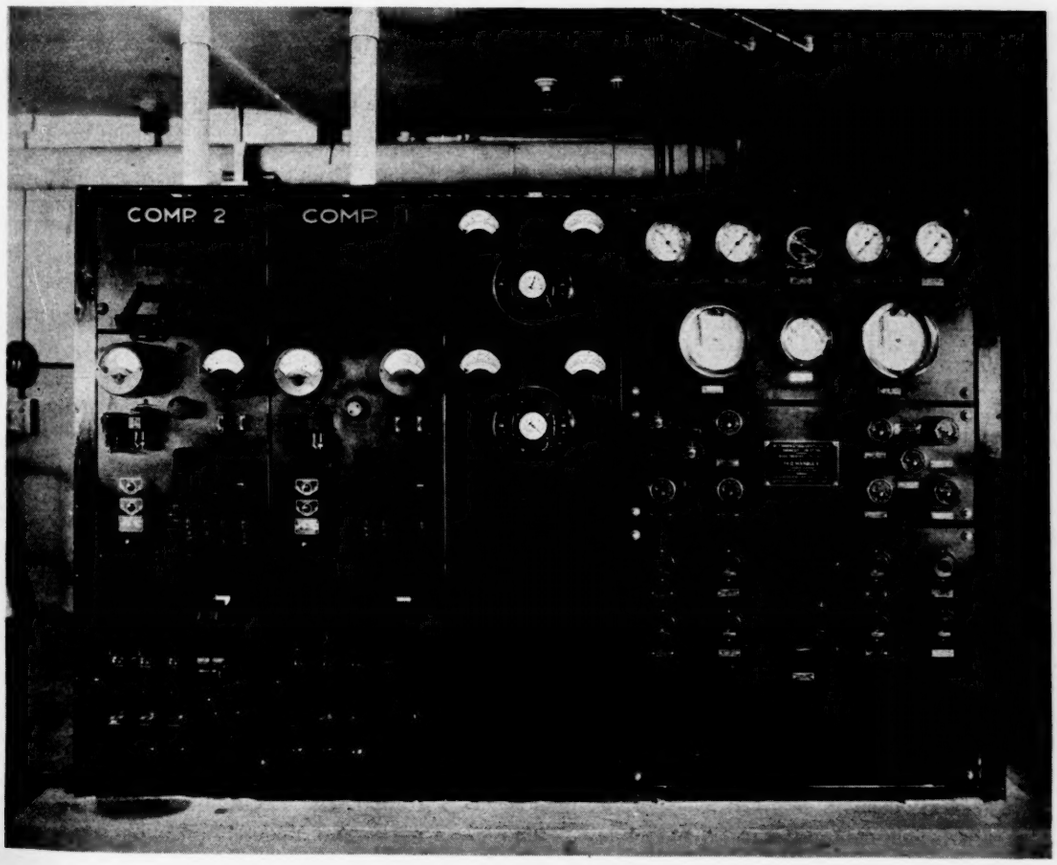


Fig. 2. Air Cooling Plant in the Palace Theater, Rochester, N. Y., Showing Compressor Motor Starting Panels, Meter Panel and Air Conditioning Panel

months should be of decided interest to the independent owner for it can be considered as so much additional profit for that short period.

Similarly, but however in a larger measure, should the operating savings figure of $143,000 in one cooling season, which can be considered as additional available for dividends in slightly over a quarter of a year, be of more than passing interest to the head of a corporation owing a chain of theaters, its board of directors and stockholders.

In any event definite savings can be effected as shown by the concrete actual example cited herein, provided some definite plan of operation is established and adhered to with really competent supervision. The following paragraphs detail some of the more essential factors entering into a comprehensive plan of operation for theater cooling plants. This plan, which was inaugurated by the author some years ago, was followed in the operation of the cooling plant mentioned hereinbefore in connection with which the savings described were made. The plan was also carried out under the author's personal supervision.

SELECTING THE OPERATING ENGINEER

The operating engineer is the human element and consequently the most variable factor in theater operation. The supervising engineer practically builds his foundation for economical operation upon him and as a consequence he should be selected with great care and deliberation—not simply hired. He should be thoroughly interviewed regarding past experience and qualifications. Past experience, if not directly that of operating theater air cooling plants, should naturally have embraced at least some of the elements of equipment constituting such plants, mainly refrigerating machines, ventilating equipment, heating plants, etc., with preference in the order noted.

ACQUAINTING THE OPERATOR WITH THE PLANT

Upon his assignment to the theater, the operating engineer should first be conducted personally through the entire plant by the supervising authority. Every piece of equipment should be thoroughly and intimately explained. This is particularly the responsibility of the supervisor, for in no better way can the confidence of the new operating engineer be gained than by realizing that his future superior does know every part of the plant and its function. The daily operating log blank should also be explained in detail during this tour of the plant, and stations at which readings are made should be brought to his attention. In plants that follow a definite program of operation such stations are printed or marked on the equipment or adjoining building surfaces. Having seen the physical characteristics of the plant, the operator's mind is certainly in a more receptive mood than otherwise to comprehend, absorb and retain everything else that will comprise his education in cooling plant operation.

Charts, diagrams and plans—and sometimes specifications—of the entire system with general operating instructions, which it is assumed the supervisor has at hand always for this purpose, should be supplied to the operator. Instructive literature supplied by contractors and manufacturers of the various elements of machinery should also be made available for study and reference.

The operator is now somewhat alive to the responsibilities of the position he has taken over and is either keenly interested in its possibilities or else he is not the type of man to carry on with further.

SCHOOLS FOR OPERATORS

If he is one of a number of engineers employed by a chain he may be given intimate instruction in operation of his cooling plant for maximum economy with others in an engineers' school. This school, or classes for operating engineers, is perhaps the most important factor in the operation schedule. Every element affecting cooling plant operation is taught and discussed in a comprehensive and systematic manner. Logs that have been selected as examples of inefficient or uneconomical operation and also those demonstrating good operation are analyzed in detail and faults or mistakes in operation are pointed out and remedies explained.

The various machines and equipment installed as part of the plant are more intimately explained and their care, maintenance, repair and operation are thoroughly covered. The operating schedule and methods are taken up from every standpoint. In other words, by making such classes a regular part of the operator's schedule, with attendance being made mandatory, the supervising engineer gradually builds up an operating force that becomes a unit of theater organization second to no other.

It may be mentioned also that such instruction or classes very readily can be arranged so that the operating duties of the engineer are not slighted in even a remote way. As a matter of fact, by systematizing his duties and following out a definite operating program under a centralized authority, the engineer can get more work done in a better way in less time than that required by haphazard operation. The operator soon finds that he is considered more than a valve and switch man and shows his appreciation of the time spent with him by his eagerness to save dollars for his employer.

OPERATING STAFF ORGANIZATION

A good many theaters maintain two operating engineers, a very few use one and fewer still use three. Many houses using two could very readily use one, particularly if such houses are chain-owned, with other cooled houses in the circuit. This is true even where a theater is open continuously from 10:30 or 11:00 a.m. to 11:00 p. m., where union engineers are employed and the theater is open Sundays. Such expedients as placing operators on ship-board shifts of four hours on and four hours off have been found satisfactory from the standpoint of maintaining the desired air conditions throughout the day and evening. Such an arrangement is usually satisfactory from the standpoint of unions and engineers. Two or three circuit engineers will take care of peak days of attendance and weather, will give one day relief for the regular operators, and will assist

AIR CONDITIONING PLANT REPORT

Building: _____ Location: _____ Date: _____

Temperature set for today: _____ Dry Bulb _____ Wet Bulb

	BDG.No.	READINGS	3:00 P. M.			9:00 P. M.			MACHINERY RUNNING TIME Hours	Minutes
AIR TEMPERATURES	1	Outside—Dry Bulb								
	2	Outside—Wet Bulb								
	3	Outside—Rel. Hum.								
	4	Inside—Dry Bulb								
	5	Inside—Wet Bulb								
	6	Inside—Rel. Hum.								
FAN	7	Discharge—Dry Bulb								
	8	Discharge—Wet Bulb								
AIR COOLER	9	Outlet—Dry Bulb								
	10	Outlet—Wet Bulb								
WATER COOLER	11	Water Inlet Temp.								
	12	Water Outlet Temp.								
PUMP	13	Start								
	14	Stop								
COMPRESSOR No. 1 (Large)	15	Start								
	16	Stop								
	17	Suction								
	18	Discharge								
CONDENSER No. 1	19	Water Inlet Temp.								
	20	Water Outlet Temp.								
COMPRESSOR No. 2 (Small)	21	Start								
	22	Stop								
	23	Suction								
	24	Discharge								
CONDENSER No. 2	25	Water Inlet Temp.								
	26	Water Outlet Temp.								

OPERATING COSTS	METER READINGS TODAY	METER READINGS YESTERDAY	CONSUMPTION	RATE	COST
ELECTRICITY					
WATER					
GAS					
OIL					
MISCELLANEOUS					
ENGINEERS					
			TOTAL DAILY COST		

PEOPLE IN HOUSE: Afternoon: Evening: Total For Day:

NOTES: Readings, Nos. 11, 12, 17, 18, 19, 20, 23, 24, 25 and 26 shall be taken one-half hour after compressor is started. Record on reverse side "Shut Down" or any other unusual condition.

Signed: ..... Engr. From: ..... To: .....

Signed: ..... Engr. From: ..... To: .....

Fig. 3. Simple Air Conditioning Report

in the general servicing of plants. The expedient of overtime pay for part or all of the four hour "off" period of the engineer on peak days of attendance and weather also helps to make the one engineer program feasible and practical. A proper selection of efficient, reliable engineers, thorough training, simple, concise operating plant reports, and an efficient supervisor all promote a program of one engineer instead of two with a decided saving in labor costs.

PLANT REPORTS

Every theater today (particularly a unit of a theater chain) is burdened more or less with forms. They cover every phase of theater operation and the employees are required to complete such forms for the main office. The air conditioning plant report, or engineer's daily report, or whatever title heads the sheet, is the form that affects the cooling plant operating engineer. Practically every theater organization has its standardized operating report. No two reports are alike although the information required from a plant and the functions of all plants are alike. There is no fundamental difference in the machinery constituting a cooling plant, for every plant, whatever its name, type or design, produces and distributes cooled air.

Some theater organizations use reports furnished by the contractor or manufacturer of the plant. These are in reality often test data sheets for either the cooling system as a whole or for the refrigerating machine. In other cases the engineer or architect retained by the owner prepares a log blank. More often though the maintenance department, or whichever department is in charge of the cooling plants, makes up one of its own. The common procedure is to use some of the items found on the different reports mentioned. Commonly, the sheet is re-designed somewhat to convey the idea of originality or to fit a certain file binder. Almost always a number of items are added that have no bearing on operation but which, nevertheless, do look imposing on the report.

The manufacturer's or contractor's test sheets are not suitable for a daily operating report from the standpoint of the theater owner or his supervising engineer, who are particularly concerned with the operating cost of the plant. The reason is that many of the items listed are of direct benefit only to the manufacturer's engineer for use in checking operating or performance characteristics of the machinery or equipment constituting the plant.

Reports prepared by maintenance departments as a rule contain so many items that have no direct bearing on plant operation that they defeat the very purpose for which they are intended. The result is that the operator does not regularly fill in all of the blanks. Where he does do so they are apt to be incorrect and consequently valueless. To fill in each item with correct readings requires spending a great deal of valuable time making out reports rather than efficiently operating the plant.

A plant report for this type of work should be concise, brief and simple and should contain only items that permit of analysis by the supervisor, and items for daily record.

One report that came under the author's observation, used by a corporation owning among others, approximately 35 cooled theaters, had a total of 285 individual spaces that the engineer was required to fill in daily in connection with the cooling plant. There were 8 additional spaces on the report that covered the heating system for winter operation. If the engineer simply sat at his desk and filled in those spaces with figures of data that came to his mind haphazardly, it would be a rather laborious and time-consuming task to fill 285 spaces. But to obtain the data specified on the report, by reading instruments, charts, recorders, indicators, gauges, thermometers, meters, and watches or clocks is a continuous duty for another engineer in addition to the one, two or more regularly employed to operate the plant, to say nothing of the staff of men required in the main office to analyze such reports if analysis is even attempted. A perusal of the report containing close to 300 blank spaces shows items such as dry bulb and wet bulb temperatures, relative humidity and effective temperatures at three individual stations in the balcony. A careful analysis of what is involved in obtaining the foregoing readings will show that if the engineer were to render an accurate record on the report of each individual reading mentioned he would spend more time getting these than would be necessary in obtaining and recording the data really required by the supervisor to determine whether or not the engineer used a dollar's worth more of water or electricity to produce the temperatures and humidities required in the theater on that particular day.

The readings mentioned are not at all necessary on any report whether daily, weekly, monthly or yearly, if

the contractor who installed the cooling system did his work properly. The duct system supplying or returning air should have been adjusted by the contractor to maintain a uniform temperature in these spaces before receiving his final payment, provided of course, his contract specified this. This adjustment, if properly made, is permanent. Consequently, the temperatures and humidities observed in any part of the orchestra or balcony are affected only by the patrons and no means have yet been found to regulate the seating of patrons in any part of the theater except, of course, by selling them definite reserved seats.

The fate of many theater reports and more particularly the cooling plant operating report is quiet and immediate burial in the files with no analysis, criticism, or study being given them. Perhaps the best and quickest way for an owner to ascertain this fact is personally to see his operating engineers or write them a letter asking how often, if ever, they have received any comment from the supervisor in the home office regarding the operating report he sends in with religious regularity, and if comments are made whether they were along the lines of operating economy and suggestions offered toward that end. The author, having interviewed many such engineers, was always met with the answer that when the report was mailed or sent to the home office it was the last he heard of it. Reports so handled can have no real significance to an operator as a means toward obtaining operating economy.

The plant report is the only guide or information available to the supervisor regarding the plants and their engineers. They permit him to practically operate the plant himself if he will use them efficiently. Consequently, if the supervisor is competent and fitted by proper experience and training himself to analyze a plant report, one of the most important factors towards operating economy has been determined.

Fig. 3 shows a simple type of air conditioning plant report. It was designed to show at a glance the operating cost for the day and the factors contributing to the cost. It also shows whether equipment is functioning as it should. Furthermore, certain of the readings inform the supervisor whether true or false entries are made by the operator. Some of the spaces are filled in by the manager or his assistant and others by the supervisor when he analyzes it, with the result that the engineer uses a minimum amount of time to record on the report the actual data covering operation required by the supervisor to intelligently analyze it from an operating economy standpoint. From this report it is a simple matter for a clerk to prepare a weekly, monthly, or seasonal summary of operating costs.

TEMPERATURES

The question as to the proper temperature at which a theater should be maintained is important both from a standpoint of operating economy and patron comfort. These two elements are closely related.

Many plants are over-refrigerated, that is, entirely too much refrigeration was provided in the original installation. Some of the reasons for this are insufficient experience of the designer, manufacturer, or contractor, depending upon who determined the capacity of the plant. Another reason is the desire of the owner to maintain 70° regardless of whether it is 75°, 95° or more outside. With oversized plants it is a simple matter to over-cool.

With plants having proper capacity the most general fault is that many are equipped with but one refrigerating machine and with no efficient method of regulating or controlling its output. With one machine designed to cool the theater when every seat is occupied on the hottest day in summer, it can be seen readily that, with milder summer weather and a partly filled house, the operator is faced with a real problem in attempting to maintain moderately cool temperatures with any great degree of economy. This difficulty only serves to stress the fact that the supervising engineer in turn must of necessity be equipped with sufficient experience himself to overcome as much as possible the faults, whims or designs of contractors responsible for such plants if he is to carry out the dictates of the owner to operate the cooling plants economically.

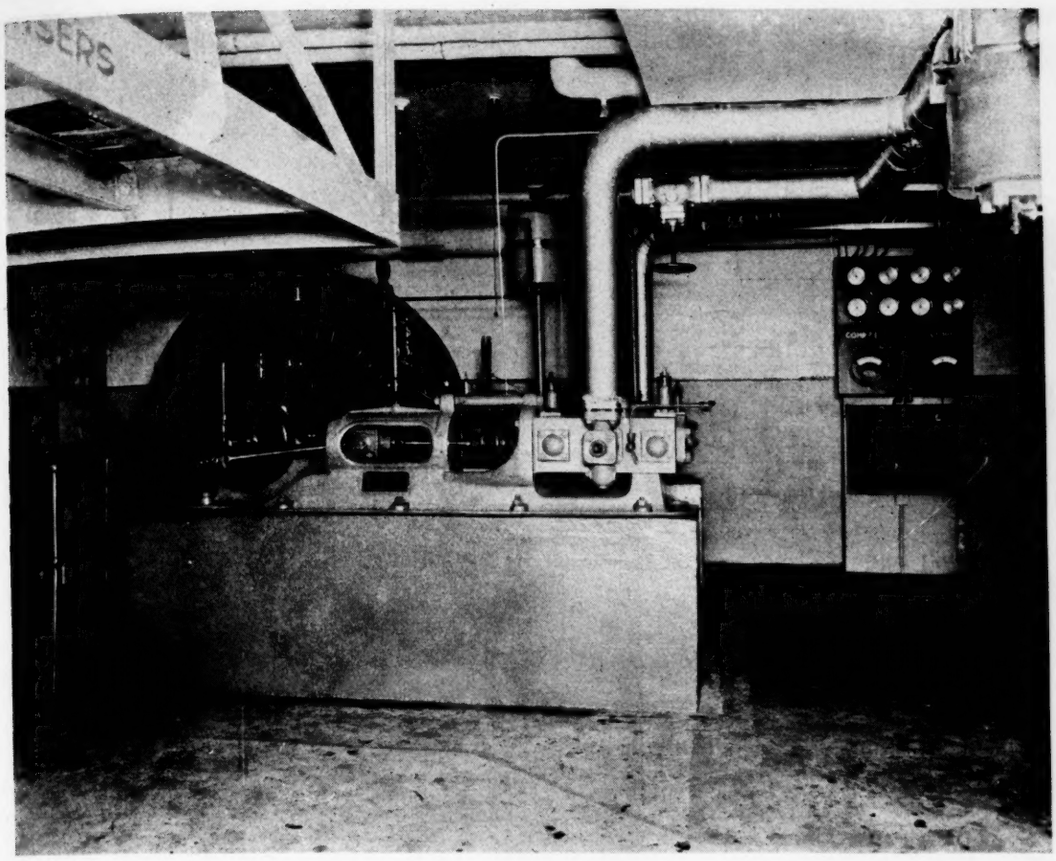
Due consideration should be given, therefore, to the handicaps imposed by over-sized plants or those provided with but one refrigeration machine, when a program aiming at the maintenance of proper temperatures is initiated and followed.

While it is not as common today as it was several years ago to maintain 70° inside the theater regardless of how hot it is outside, the fact remains that patrons complain daily of cold theaters. The owner after spending thousands of dollars for the plant which produces the cold, although feeling that the public is grossly ungrateful, satisfies himself with the thought that the patrons simply do not know what they want. Yet cold theaters do exist and the owner pays in two ways, first through loss of patronage and second in electrical, water and other bills for operation. Comfortable temperatures can be maintained and it is decidedly economical to do so. It can also be stated that temperatures which will prove comfortable to all weather patrons can be predetermined with considerable accuracy. Practical data are available covering the most suitable temperatures and humidities to maintain indoors with any condition outdoors. Such data can and are being applied to the determination of proper air conditions in theaters.

OPERATION

In general, operating instructions to engineers should specify when plants should be started and stopped in rotation to show starting and ending time; how to air out the house in the morning without using the refrigeration or placing a burden on the refrigerating machines when they are started; water pressures to be maintained on the air washer nozzles; how to bring the temperature of the house down when the show starts at a minimum expense of refrigeration; the most economical pressures to maintain on the refrigerating machine; ways and means to conserve on refrigerant and lubricating oil; explanation of the various automatic control instruments, dampers, etc.; care and maintenance of all equipment.

Many plants are equipped with recording instruments



One of the Two Duplex Compressor Units and Refrigerating Gauge Board in the Air Cooling plant of the Palace Theater, Rochester, N. Y.

of some type or other supplied by the contractor either as a requirement under his contract or as a regular feature of this system. The most general types are dry bulb temperature recorders. Very rarely are plants equipped with dry and wet bulb recorders for both outside and inside conditions, whereas these are most essential if any attempt at all is made to operate economically or to operate under definite pre-determined temperatures and humidities inside the theater in relation to existing outside conditions. Some theater cooling plants are equipped with every conceivable device to automatically "control" or "regulate" the temperatures and humidities desired, others have little or no such equipment. Yet it is a fact that no cooling plant automatically controls or maintains definite temperatures with required humidities, neither is any plant equipped with automatic devices that regulate or control the output of the refrigerating machine in definite relation to the fluctuating patron load of a theater.

Similarly, no plant is equipped with automatic control which will maintain a fresh air damper in a full open position when the wet bulb temperature of the air is lower than the wet bulb temperature of the return air. These are only a few of the reasons for the necessity of thoroughly educating the engineer in every phase of plant operation.

The supervising engineer in charge of operation will soon find that a perfect circle on a chart from a dry bulb recording instrument is no criterion to good or economical operation but that it was obtained rather at the expense of water and electricity. Some automatic control is desirable in connection with air conditioning plants in theaters but it would be in the main for winter operation.

The fresh air damper should be under the control of the operating engineer either by means of a convenient switch on the pneumatic system or by a hand damper. With such equipment and with wet and dry bulb recording instruments for outside and inside as a guide, the engineer can admit air to the system having the lowest wet bulb temperature, thus economizing on refrigeration. No automatic equipment on any plant accomplishes this.

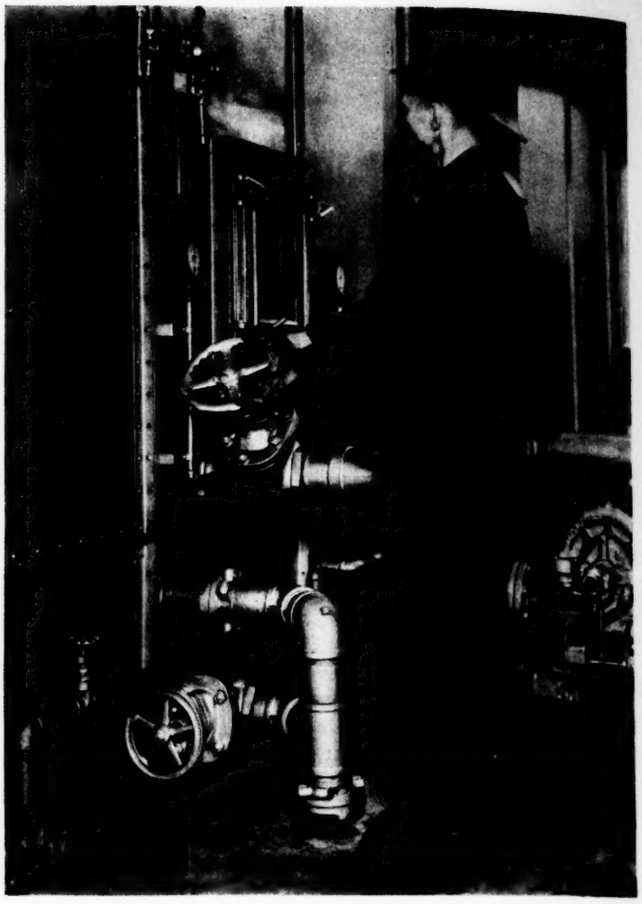
To obtain the required humidity in the theater, the engineer should operate the refrigerating machine to maintain the proper water temperature in the air cooler. No automatic equipment in the plant does this.

Finally, to maintain the proper temperature in the theater, the engineer would regulate the damper controlling the admission of return air directly to the fan; automatic equipment may be made to carry out this function of the plant provided the operator adjusts the thermostat to the point desired, when necessary.

It can thus be readily seen that economy in operation of a cooling plant is decidedly a question of the vigilance of an operating engineer plus the close observance and attention of a supervising engineer.

Fig. 2 will show an air conditioning plant operating board designed primarily to assist in maximum operating economy. On it are located wet and dry bulb recording instruments for outside and inside air; indicating thermometer for water temperatures in the air cooler tank and for condenser water inlet and outlet temperatures; gauges showing air and steam pressures and vacuum on the heating system; manual switches for outside, return, and by-pass air dampers; stop buttons for all theater fans and indicating running lights and stop button for main exhaust fan; eight-day clock.

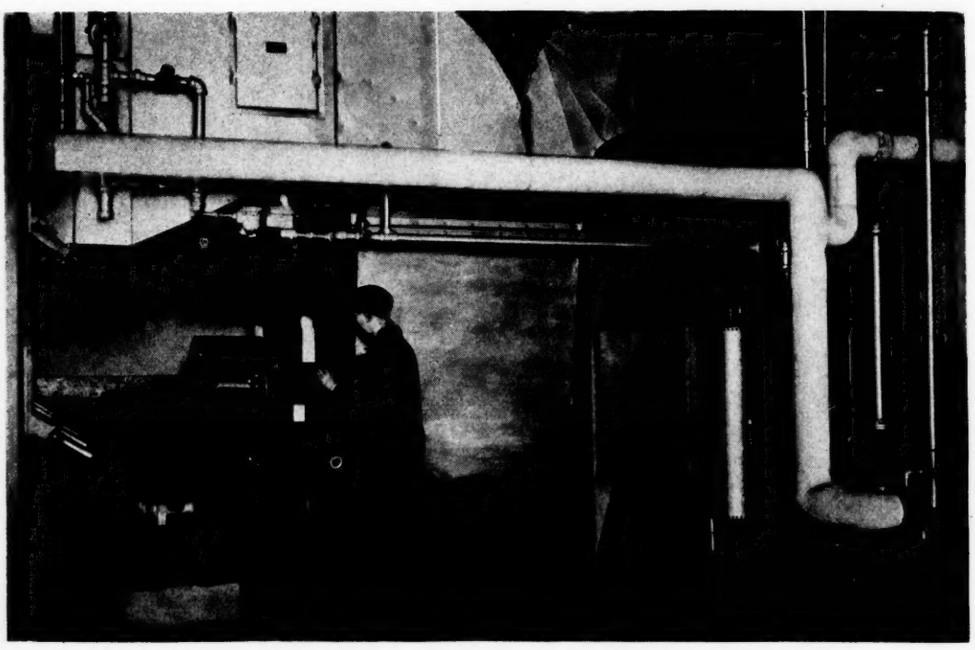
Ventilating an Engineering Research Laboratory



Operator Opening Valve to Sprays and Observing Action of Spray Through Window. Dew Point Control Shown at Upper Left Center

TWO new buildings added to the East Pittsburgh Works of the Westinghouse Electric and Manufacturing Company make use of a central-fan-and-ducts method of heating. Although neither of these two buildings contains any artificial cooling equipment in connection with the plan, they are nevertheless air conditioning plants in that air washers are included.

Both buildings are steel frame and masonry structures. The first is an addition to the research laboratory located some distance from the main plant and houses the extensive research activities of the company. The central engineering laboratories building, centrally located, is to house the development work which is concerned largely with product development and which is now carried on in a number of smaller isolated laboratories. Not only does this building, now substantially



Air Conditioning Equipment for Basement, with Air Washer Shown on Right. Piping in Foreground Runs to Vacuum Pump for Entire Building

completed, present many unique detailed arrangements because of the necessity of accommodating itself readily to unforeseen changes, but it is also unique in that it is one of the largest buildings to date in which the steel frame is entirely electrically welded.

The engineering laboratory is twelve stories in height and 120 ft. x 220 ft. in ground plan. Side walls are of brick. Steel sash is used throughout and while swinging sections are provided in each window these sections are locked to prevent opening, as it is felt that their indiscriminate use will interfere with the intended operation of the central fan system. An interesting feature of the window construction is the provision of a small drainage groove in the tile which forms the sill whereby any water forming on the inside of the windows will be caught and discharged without the possibility of its running on the side wall and floor.

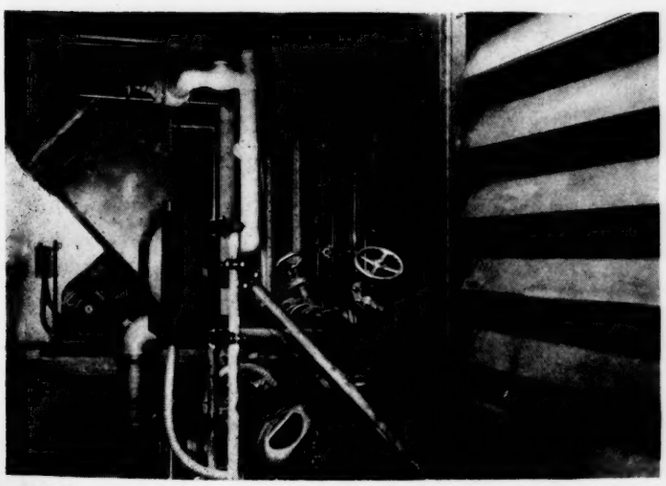
The five lower floors of the building are designed for use as laboratories proper while the upper floors are used for office space. A central hall runs lengthwise of each laboratory floor. Doors communicate with rooms located on both sides of the hall.

On the lower floors partitions are placed at intervals to subdivide the space into rooms. While these rooms are roughly uniform in size there is some variation. Each room is treated more or less as a unit as in many cases it is evident that these rooms will have to accommodate a variety of apparatus which will vary from time to time because of the nature of all laboratory work. The upper floors are not divided permanently but individual offices are formed by the use of removable partitions of the type so widely used for office spaces.

Each of the laboratory floors is fitted with its own central fan, washer and trunk duct. A similar central apparatus is installed on the lowest office floor to serve all the floors above. While these installations are essentially similar they differ considerably in detail since the laboratory floors offer a different problem in operation than do the office floors. All of the four installations on the laboratory floors are practically duplicates.

The fan and washer in each case is located in a room

Ventilating Equipment for Office Floors with Recirculating Air Damper at Right Front. Air Observation Window to Air Washer and Pressure Gauges Shown above Pump



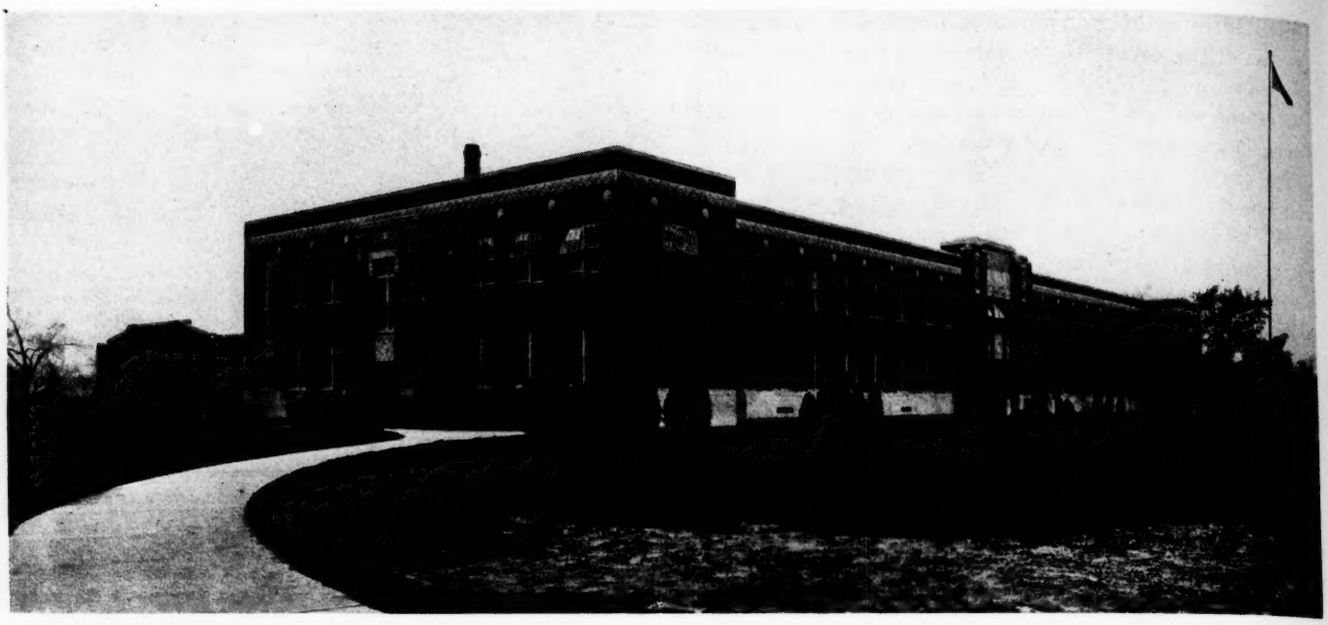
Laboratory Room with Air Outlet Shown in Upper Right. Air Motor, and Lever Mechanism for Controlling Air Dampers, Shown Below Outlet. Valve Controlling Steam at Left of Outlet, and Thermostats Controlling Both Dampers and Steam Valve Shown on Wall at Left of Door

near the center of the building longitudinally. Air is passed through a heating coil, through the washer and fan and is discharged into a trunk duct built into the ceiling of the corridor, or hall. Openings from this duct lead to the rooms at the sides. These openings are spaced one to the bay, and each room has one or more openings, depending on its size.

At each supply opening a damper and heating coil are mounted in the branch line and are under thermostatic control located close to the supply opening. With this arrangement it is possible to secure individual control and adjustment of the air leaving each supply outlet and the control is available for local adjustment. This individual control was considered necessary because of the diversified use expected of individual rooms. The supply outlets are located well above the floor so that there is no direct draft on the occupants.

Provision is made for recirculating the air through the apparatus. Louver openings are left in the doors communicating with the corridor. Recirculated air passes through these louvers located near the floor level and through the corridors to an intake communicating with the inlet to the fan and washer. The fan-and-washer apparatus is also connected to outside air. It is thus possible to take the entire air supply from the outside or from the inside or to mix these two supplies in any desired proportions. Louvers in the outside wall are also provided so that when no recirculation is desired the air may be discharged directly out of doors.

The supply of air to the office floors may likewise be circulated. Trunk ducts in the corridor ceilings also carry the supply as in the lower floors. The chief difference between the plant for supplying the office floors and those for the lower floors lies in the omission of individual heaters and automatic dampers at the outlets. The outlets on these floors are connected to the trunk with grilled openings. Dampers at these grilles permit regulating the air supplied but the temperature control is centralized on these floors.



Architects, Fowler & Karges *Engineers, Lewis, Warren & Ronald*

Lincoln School, Evansville, Indiana

Corridor Venting in an Indiana School

THE Lincoln High and Elementary School for the Colored, at Evansville, lays claim to the distinction of being the first school in Indiana to employ corridor venting to classrooms. Indiana codes require some form of outside exhaust for classroom atmospheres. For the most part, rulings on this subject within the state have been highly conservative, so that, apart from two or three seprate districts in the state, one hardly looks for any new departure in school engineering plans.

Classrooms, auditorium-gymnasium, and shop are heated and ventilated by means of a combination of unit ventilators and direct radiation. All other rooms rely entirely upon direct radiation. Radiators are wall-hung or otherwise wall-supported well above the floor level.

Piping is of wrought iron, except such sections as are run underground in tile, these being of brass. Steam supply mains direct from boiler head are carried overhead in the roof space. Return mains are hung in tunnels that follow the contours of foundation walls. The boiler room is somewhat below ground level at the end of the auditorium-gymnasium wing.

Radiation and unit ventilators total as follows:

	Volume of Air, c.f.m.	Equivalent Direct Radiation, Sq. Ft.
4 Unit Heaters	14,000	6,720
33 Unit Ventilators	37,200	15,180
	51,200	21,900
Direct Radiation		6,508
Total		28,408

Recirculating units are used. The favored location for classroom unit ventilators is on the outside wall, close to the middle. Capacities of the units range from 750 to 1,250 c.f.m. Auditorium and shop unit heaters are provided with capacities of 3,000 and 4,000 c.f.m. each, respectively.

Supplementary radiators in classrooms are installed beneath the windows. Where only direct radiation is furnished, one thermostat controls room temperatures. All corridors have separate thermostats for every radiator installed. Vestibules are treated individually as separate rooms.

Within each classroom a compound thermostat controls the direct radiation and the mixing damper in the unit. The manual training shop is equipped with two compound thermostats for servicing the unit heaters and direct radiation. A separate manually-operated switch controls the dampers of the ventilators in the roof. The auditorium-gymnasium is similarly equipped with two simple and two compound thermostats.

Fresh air supplies to classroom are ample, far in excess of actual oxygen needs for fullest occupancy. Control is set for close and quick response to room requirements. Air exhaust is by means of corridor venting through grilles in doors close to the floor line.

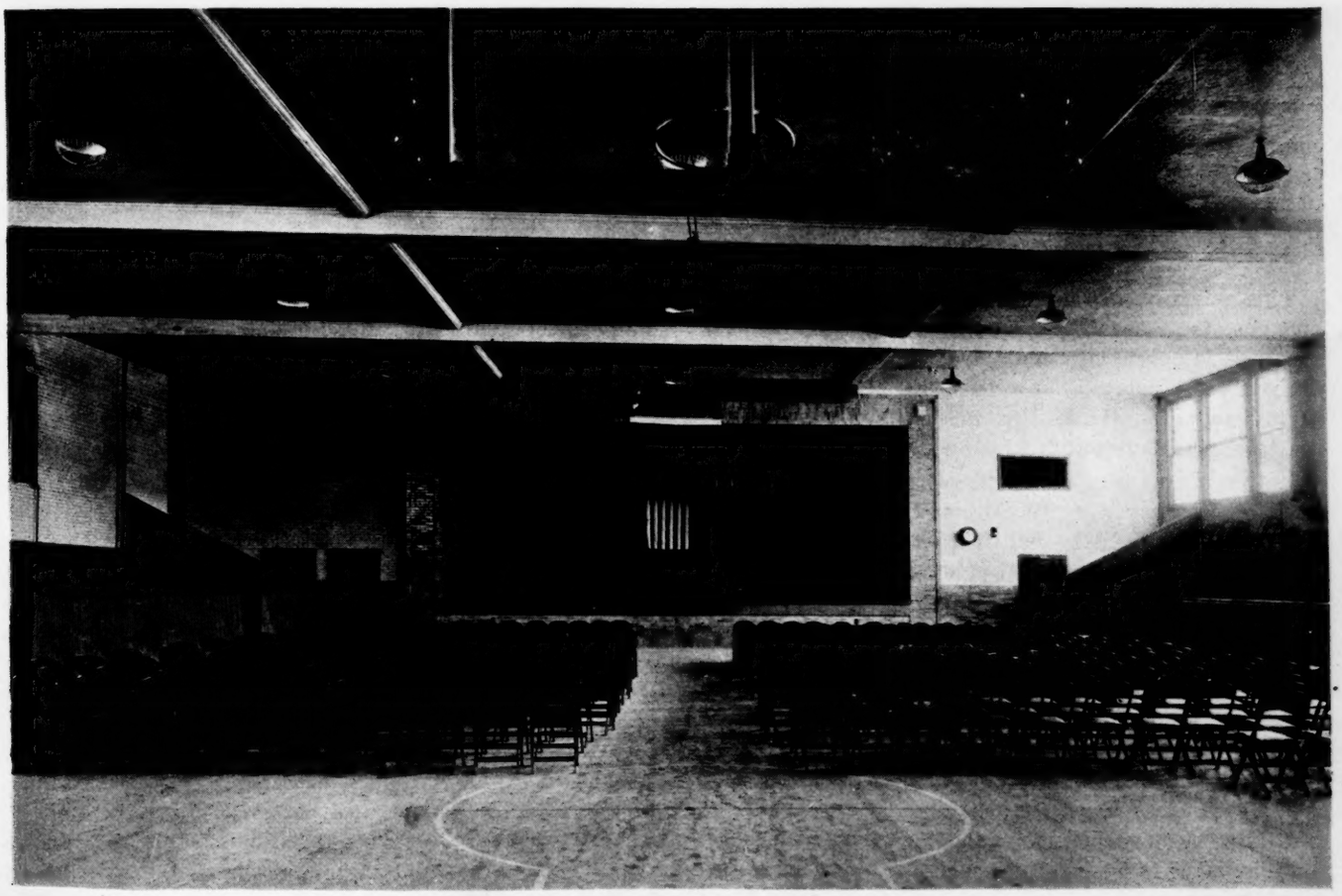
Air properly heated is introduced through ventilation units at the outside wall. The velocity of the fresh air current and its volume are such that the air strikes the ceiling with some force. It spreads and is forced downward with an oscillating movement that diffuses the heat evenly, breaking up any tendency toward static air enveloping individual occupants of the room, and resulting in a pleasant feeling of air movement without draft.

The ventilation scheme employed in the High and Elementary Colored School at Evansville provides a special forced exhaust for fumes generated in the chemistry room. Toilets are individually exhausted through

Corridor on Second Floor. Bottom Panel of Door is Made of Heavy Screen. Grilles are Shown on the Ceiling

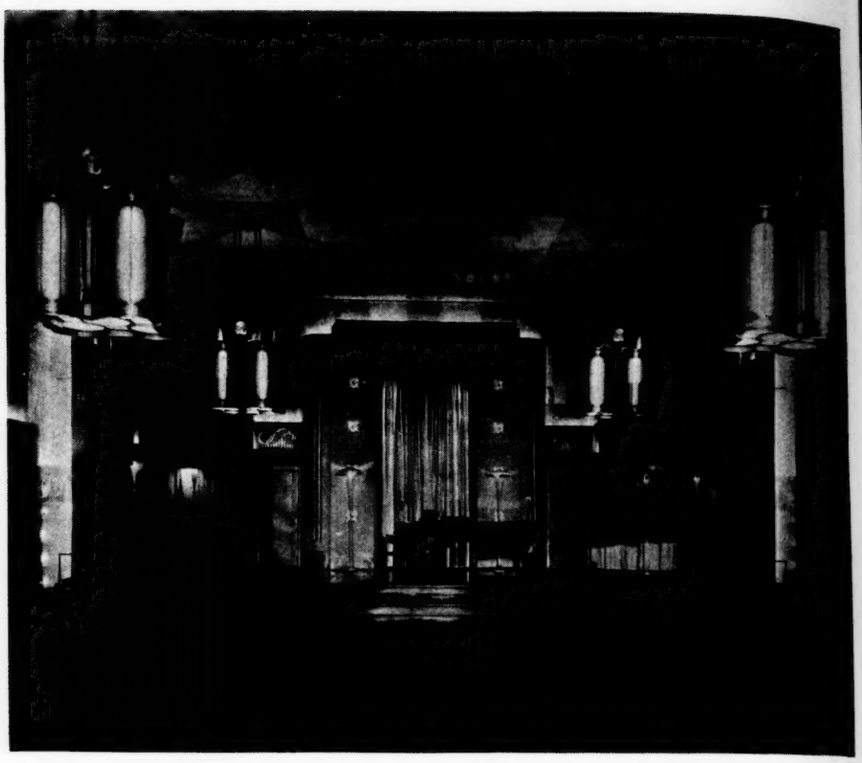
the roof, as are all lockers and certain service rooms. A separate system of fan exhaust through the roof takes care of domestic science and other rooms where special ventilation problems are presented. Exhaust ducts from these systems connect in the attic space to an acid-proof fan in the roof. All ducts are finished on the inside with acid-resisting paint.

The shop and the combination auditorium-gymnasium have received separate treatment with individual ventilators in the roof. All roof ventilators are manually operated by means of special switches in the boiler room. Fresh air supplies can be increased or diminished according to occupancy, and the exhaust can be speeded up by opening more roof vents, or retarded by closing any or all vent dampers. These spaces are separate units and can be cut off except when in active use.



Interior of the Gymnasium-Auditorium, Lincoln School

Fig. 1. A Broadcasting Studio Air Conditioned for Comfort and the Health of the Performers



Air Conditioning

by **William Hull Stangle**

IX—Atmospheres and Psychrometry

by **Realto E. Cherne***

SOME attention has already been given to the constituents of atmospheric air. We have noted that it is essentially a mechanical mixture of oxygen and nitrogen together with slight quantities of other rare gases.

This mixture, often considered as one gas, is everywhere present and unless it is specifically and carefully excluded, all processes of manufacturing and of ordinary life and living take place surrounded by air.

If this air were always fully suited in all its properties to the use to which it is desired to put it there would evidently be no need for changing or modifying it in any way. Fortunately, the great majority of its uses require little or no changes in the free atmospheric air. Others do seem to require that it be changed somewhat. Some few seem to require very marked changes.

There are two ways in which an unsuitable atmosphere can be made suitable. One is by carefully excluding the existing mixture of gases from a space and substituting in its place other gases or a mixture of other gases. In other words, a synthetically, or artificially, prepared atmosphere may be made to take the place of the usual atmospheric mixture of gases. The second way is to keep essentially the normal atmosphere present but to introduce into it or extract from it those substances or materials which will give the resulting mixture the constituents and properties which will render it suitable.

Cases where a wholly synthetic atmosphere is of enough value to justify its use are rather rare. Among the interesting applications is the case of certain welding operations which are sometimes carried on in an atmosphere of pure hydrogen which is obtained by directing a screen or jet of hydrogen at the point where the fusing is taking place. Synthetic atmospheres have been experimented with and have been used to some extent in tunnelling operations where "bends" have occurred when workmen have been exposed to compressed air having the usual constituents.

Methods have come into existence in the treatment of certain diseases where very considerable changes have been made in some of the constituents and properties of the atmosphere. In such uses, while the mixture of gases is synthetic in a sense in that foreign gases are introduced into the natural mixture, the greater part of the mixture continues to be the original gases. Oxygen tents and oygen chambers have been used and the process is essentially one of enriching the oxygen content of the existing atmosphere rather than using a wholly new mixture of gases.

It will be seen that the cases mentioned are distinctly specialized problems and their application ordinarily does not involve the use of great volumes of artificially prepared mixtures. It would be quite possible to produce in a laboratory an atmosphere having virtually any proportion of any gases desired but such a procedure is expensive. Resorting

*Carrier Engineering Corporation.

to this method is therefore logical only where the suitable properties can be obtained in no other way.

In the cases of most common occurrence, the changes required are relatively slight compared to those just described. It is entirely logical in such cases to merely change the constituents or "conditions" of the available atmospheric air rather than attempting the alternate procedure. Where such changes are necessary or desirable they usually involve a change in one or all of the following:

(a) A change in the temperature of the air,

(b) A change in the moisture content,

(c) A change in the incidental, or minor, constituents of the atmospheric mixture, such as odoriferous gases, incidental CO_2, etc.

While the present situation regarding nomenclature is confusing, the term "air conditioning" is commonly used when referring to methods or processes of accomplishing these changes in order to adapt atmospheric air to specific uses. As an engineering term its use implies moving the air so treated into and out of the space where it is to be used, and the means and apparatus for so doing, as well as the mere process of accomplishing the desired changes in the air itself.

Applications of two general kinds arise:

1. Where the atmospheric air is so changed and used as to produce or promote the comfort of humans, and

2. Where the end sought is to produce an atmosphere which will assist or make possible the carrying on of some process, usually commercial or industrial.

In the main, the ends sought in these two classes of application are so different that the classification is a rather natural one. There is, however, no difference in the fundamental principles. Often, though, there is a considerable difference in the details of equipment not only between the two classes but individual applications in the same class as well.

Comfort conditioning has been applied to many classes and kinds of buildings, prominent among which are theatres, restaurants, department stores, banking rooms, and office buildings. Industrial conditioning has been used in some 200 manufacturing processes including baking, candy-making, meat-packing, tobacco, textiles of various kinds, moving pictures, and ceramic products.

In practically all applications the matter of moisture content in the atmosphere is of paramount importance. The presence or absence of this moisture and its state in the air very profoundly affects many industrial processes as well as the reaction of people to their air surroundings. It will be noted that in the industrial applications just mentioned the materials are hygroscopic, i.e. they are capable of seeking moisture equilibrium with the air. The fact that moisture in the air affects humans both physiologically and psychologically is too well known to need comment.

In applying the idea of making changes in the natural atmosphere it is therefore necessary to consider the air not as a mixture of gases but rather as a mixture composed of a gas and a vapor. The vapor is the vapor of water, or steam. Before attempting to make even the most elementary calculations, it is absolutely essential that the properties of a mixture of air and steam be known, that the relations of the constituents to each other be fully understood, and that the effects of changes in the temperature of the mixture be clear.

The two substances are generally assumed to be so intimately mixed that both are at the same temperature while each carries its own properties into the mixture. The properties of the mixture at any temperature cannot be fully determined unless this point is clear.

Before proceeding further several terms which continually occur should be defined.

The sensible heat of air is heat due to the temperature of the air, as indicated by the dry bulb temperature. In other words, *dry bulb temperature* is the measure only of the intensity of heat above 0°.

A cooling effect is noted if a silk envelope is placed upon the bulb of a thermometer and then thoroughly wet with water. If this thermometer is then whirled in the air at a rate of 100 or more revolutions per minute for about one-half to three-quarters of a minute, an equilibrium will be set up from which humidity determinations are conveniently made. By definition, the *wet bulb temperature* is that constant temperature which a body of water will assume if free to evaporate into the atmosphere, providing that its necessary heat of evaporation come from the atmosphere alone. The difference in the temperatures indicated by the wet and dry bulb is called the *wet bulb depression.*

The *dew-point* of the air containing a given weight of water vapor is the temperature at which this water vapor in the air becomes saturated. Further reduction in temperature will cause condensation. The dew point is also reached when air is saturated along the wet bulb line, adiabatically, until the wet bulb and dry bulb are the same. Adiabatic saturation is brought about without addition or subtraction of heat from an external source. Complete saturation occurs when the wet and dry bulb temperatures become the same. This is the adiabatic *saturation temperature.*

Just as the dry bulb is a measure of the sensible heat of the atmosphere, the wet bulb is a measure of the total heat*, and the dew-point is a measure of the total moisture content.

Absolute humidity may be defined as the actual weight of water-vapor contained in a unit weight or unit volume of air. It is customary to give this value in grains of water per cubic foot of air.

Although it is often said that dry air absorbs moisture, the air serves actually as the carrier of the heat necessary to evaporate the water. When the atmosphere contains less moisture than is necessary for saturation *at a given temperature,* the moisture content is usually expressed in terms of *relative humidity*: that is, as a ratio of the weight of vapor actually present to that which might exist if the air were saturated at the given temperature. For example, assume that we have air at 70° F. containing four grains of moisture per cubic foot. By reference to the psychrometric chart (Fig. 2) we find that air would contain eight grains of moisture per cubic foot when saturated at 70° F. For this condi-

*Definitely demonstrated in "Rational Psychrometric Formulae" by W. H. Carrier. Trans. A.S.M.E., 1911, Vol. 33, p. 1005.

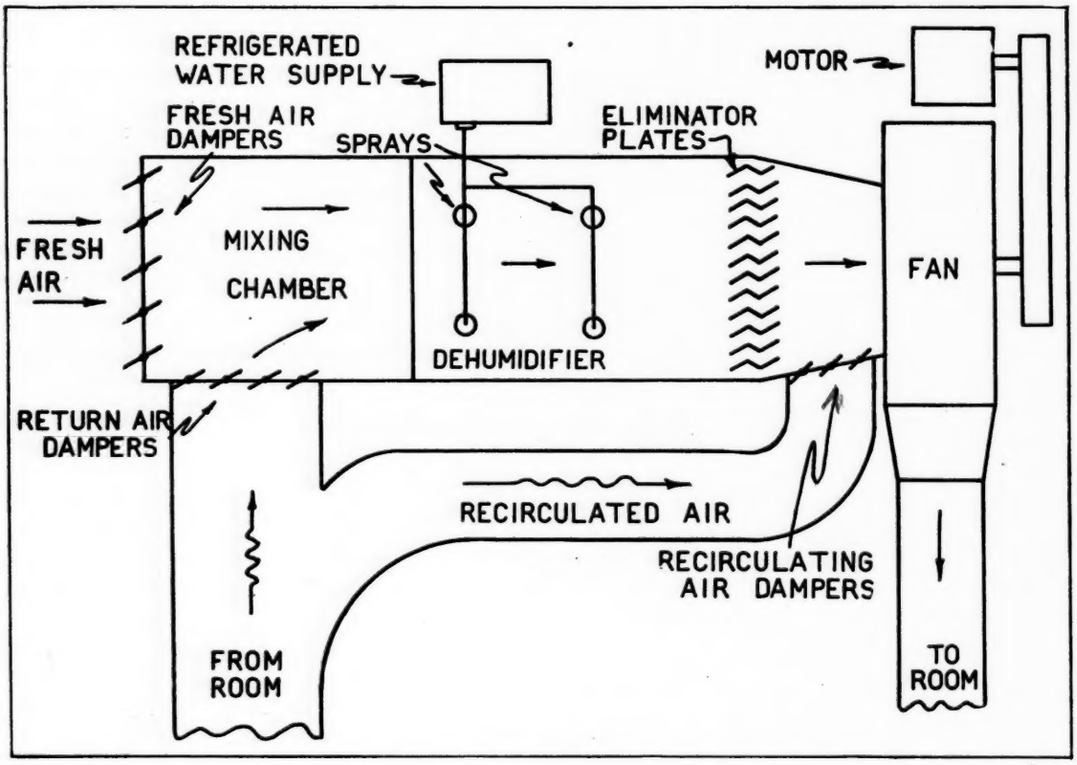


Fig. 2. Diagrammatic Sketch of Typical Modern Air Conditioning Layout Using Refrigeration

tion the relative humidity may be said to be 50%.

The *total heat* of air is composed of both the sensible and latent heat; the former being due to the temperature and the latter being the latent heat of vaporization of the moisture in the air.

A liquid or a solid, upon changing state into a gaseous form, expands. The constituent molecules then move at a faster velocity. *Vapor pressure* results from these molecules moving at a high velocity and is manifested as pressure when the molecules strike a restraining surface. Vapor pressure, then, is a measure of the molecular activity of the vapor or the expansive force of the vapor.

It is assumed that the reader is familiar with Charles' Law of Absolute Temperatures, Boyle's Law of Absolute Pressures, and Dalton's Law of Partial Pressures, since each is important in understanding solutions to air conditioning problems.

The four fundamental principles of evaporation are listed below. Incidentally, a thorough understanding of these brief paragraphs indicates an understanding of the basic principles of air conditioning.

PRINCIPLES OF EVAPORATION

1. When dry air is saturated adiabatically the dry bulb temperature is reduced as the relative humidity is increased, and the decrease in sensible heat of air and water vapor is exactly equal to the simultaneous increase in latent heat of evaporation.

2. As the moisture content of the air is increased adiabatically, the temperature is reduced simultaneously until the vapor pressure corresponds to the temperature when no further heat change is possible. This ultimate temperature may be termed the temperature of adiabatic saturation.

3. When an insulated body of water is permitted to evaporate freely in the air, it assumes the temperature of adiabatic saturation of that air and is unaffected by convection. That is, the true wet bulb temperature of the air is identical with its temperature of adiabatic saturation.

From these three fundamental principles, there may be deduced the fourth, which states:

4. The true wet bulb temperature of the air depends entirely on the total of the sensible and latent heat in the air and is independent of their relative proportions. In other words, the wet bulb temperature of the air is constant, providing that the total heat of the air is constant.

There have been several methods used to increase or decrease the moisture content of the air. Although chemical absorption and surface cooling have been used with success, by far the greatest part of present day air conditioning is accomplished by means of the direct spray method in which water of controlled temperature is sprayed into the incoming air and then free moisture eliminated. With a well designed washer used for dehumidifying, the air comes out saturated at a temperature within one or two degrees of the final spray water temperature. For example, in dehumidifying the water may enter at 40° and leave at 45°, the air should then leave at about 46° or 47°. Bearing in mind that the absolute humidity, or weight of moisture carried per cubic foot of air in a saturated condition, is dependent solely and entirely upon the temperature at which it is saturated, it is evident that by supplying the proper amount of this saturated air and regulating the temperature of the conditioned spaces, the relative humidity is automatically provided for. The air passing through the dehumidifier may be regulated both as to amount and temperature to provide the necessary amount of moisture to meet varying room conditions. Any variation of the moisture content of the air in the building will be due to the evaporation

from people or processes, or from infiltration. A properly designed system can maintain the latter at a rather low amount when considering the volume of air being handled.

Refer to Fig. 2 for a diagrammatic sketch of a typical modern air conditioning layout using refrigeration. Fresh or outside air enters the mixing chamber as is shown, where it combines with the return air before being drawn through the dehumidifier. The temperature of the saturated air leaving the chamber is regulated both by controlling the temperature of the spray water and properly portioning the mixture of outdoor and return air. After being drawn through the eliminator plates, which rid the air of unevaporated free moisture, in systems using the recirculation method the air is mixed with recirculated air before entering the fan to be supplied to the distributing system heaters, or condenser water. For winter operation, the only changes necessary would be to place a set of preheaters (which prevent freezing of the sprays) in the fresh air intake and a set of reheaters (which raise the temperature of the air after humidification to a controlled point sufficient to maintain the desired conditions in the room to which it is delivered, and provide for heat losses when necessary). These heaters are located either in the fan inlet chamber, recirculated air chamber or main supply duct. Naturally, the use of refrigerated water will be unnecessary. In its place, the spray water may be recirculated as is done in common practice.

Quite often there is confusion in the use of the two terms "return air" and "recirculated air." *Return air*, in the language of air conditioning, applies to the air that is taken back from the conditioned area and again passed through the washer or dehumidifier for treatment. Use of this air, on hot days in summer and cold days in winter, effects a considerable saving of refrigeration effect in the former, and the heating effect in the latter.

The term *recirculated air* is applied to air, also taken back from the conditioned area, which by-passes the washer and goes directly into the fan to be again supplied to the room. This air is mixed with the air passing through the dehumidifier and thereby serves to cut down the temperature differential between the air entering the room via the air conditioning system and the room temperature. Its use also effects considerable savings in costs of operation. Another important use of recirculated air is that it may be utilized to increase the total air quantity supplied to a room to promote adequate circulation, whether or not the heat load requires that amount, without increasing the refrigerating or heating capacity proportionally. In addition, it allows a constant air supply quantity to be used regardless of a fluctuating heat load, without over cooling, or over heating, and thus insures proper circulation as provided for under maximum load conditions. It should be noted that use of recirculation does not impair the ventilating qualities of the air since in common practice there is always sufficient outside or treated air introduced into the system to insure quality.

The subject of recirculation should not be concluded without mention of the fact that there exist certain patents which limit this by-passing of the washer to contractors properly licensed by holders of these patents.

With the various terms clearly understood and the laws of evaporation in mind it is quite possible to calculate the heat interchanges, and the heat contents of any given mixture of steam and air. However, so long as the total pressure is constant the work involved may be very greatly lessened by the use of a chart. Fig. 3 is a reproduction of such a chart covering dry bulb temperature ranges of 20° F. to 110° F.

The following problems illustrate the use of these charts. In these problems we have referred to Curve A, Curve B, etc. These curves are marked as follows:

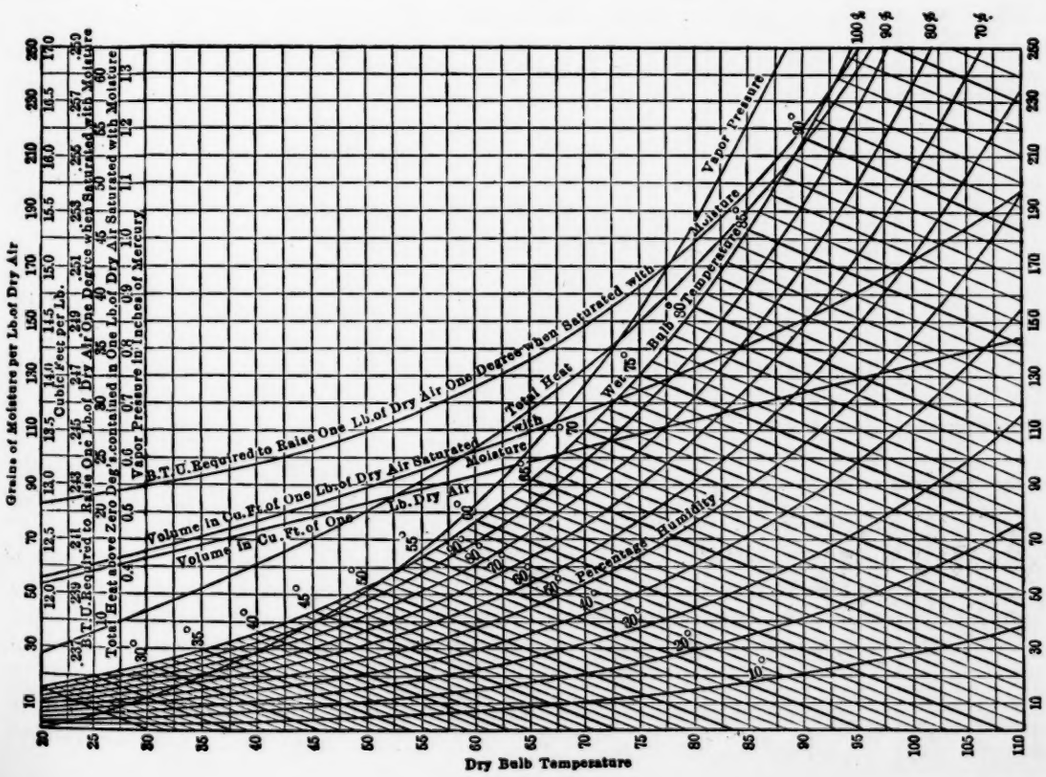
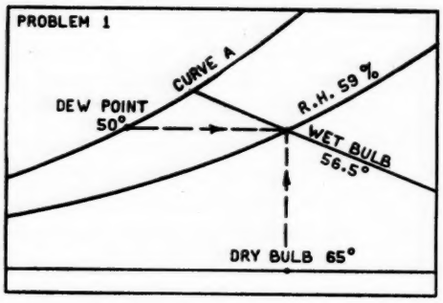
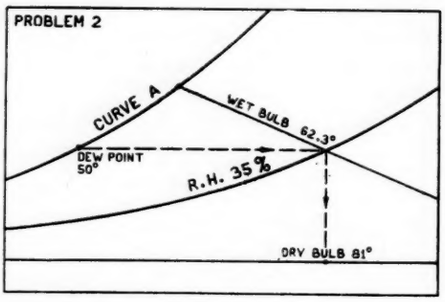
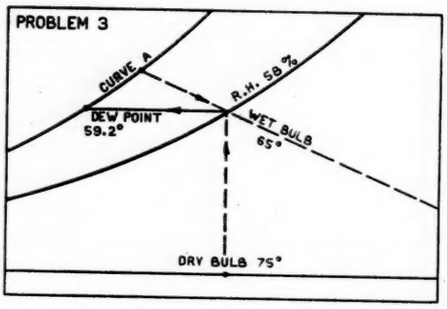
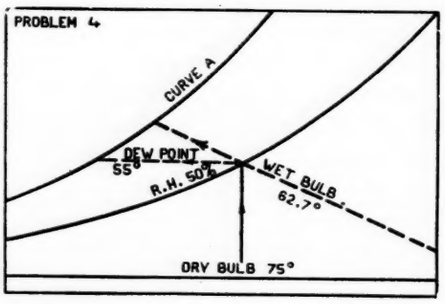

Grains of Moisture per Lb. of Dry Air
Dry Bulb Temperature
Vapor Pressure
Moisture
Wet Bulb Temperature
Total Heat
Percentage Humidity
Volume in Cu. Ft. of One Lb. of Dry Air
Cubic Feet per Lb.
B.T.U. Required to Raise One Lb. of Dry Air One Degree when Saturated with Moisture
Total Heat above Zero Deg. Contained in One Lb. of Dry Air Saturated with Moisture
Vapor Pressure in Inches of Mercury

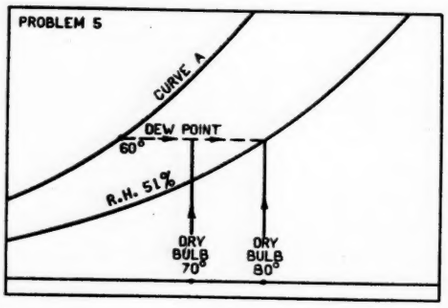
Fig. 3. Psychrometric Chart. From "Fan Engineering"

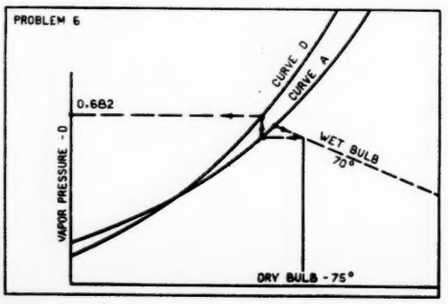












CURVE A—Wet Bulb Temperature.

CURVE B—Volume in cubic feet of one pound of dry air saturated with moisture.

CURVE C—Volume in cubic feet of one pound of dry air.

CURVE D—Vapor Pressure.

CURVE E‡—Grains of moisture per cubic foot of saturated air.

Problem 1. Given a dry bulb temperature of 65° and the dew point temperature as 50°. Find the relative humidity and wet bulb temperature.

Follow the vertical line of the 65° dry bulb temperature up to the intersection of a horizontal line drawn through the dew point found on Curve A. This point indicates a relative humidity of 59% on the curved lines running upward to the right, and a wet bulb temperature of 56.5° on the diagonal lines running downward to the right.

Problem 2. Given a relative humidity of 35% and the dew point as 50°. Find the dry bulb and wet bulb temperatures.

Follow the horizontal line through the point on Curve A representing 50° dew point to its intersection with the curved line representing 35% relative humidity. Read vertically downward to find a dry bulb temperature of 81°. Read upward to the left along the wet bulb temperature lines to find, by interpolation, a wet bulb of 62.3°.

Problem 3. Given a dry bulb temperature of 75° and a wet bulb temperature of 65°. Find the relative humidity and the dew point.

Locate the point of intersection of the 75° dry bulb temperature with the oblique line running downward to the right from the 65° wet bulb temperature on Curve A. By interpolation, the relative humidity, on the lines running upward to the right, is found to be 58%. A horizontal line drawn through the intersection to Curve A gives a dew point of 59.2°.

Problem 4. Given a dry bulb temperature of 75°, and a relative humidity of 50%. Find the dew point and wet bulb temperature.

Draw a vertical line from 75° on the lower scale upward to its intersection with the relative humidity lines which curve upward to the right. Through this intersection draw a horizontal line to the left. The point where it intersects with Curve A will give the dew point, 55°. A line through the intersection of the 75° dry bulb line and the 50% relative humidity line, drawn upward to the left along the wet bulb lines will give the wet bulb where it intersects with Curve A. 62.7°.

Problem 5. Given a dew point of 60° and a dry bulb of 70°. Find the relative humidity if the dry bulb is increased to 80°, the dew point remaining constant.

Draw a vertical line from the lower scale through the dry bulb temperature, 70°. Locate the 60° dew point on Curve A and draw a horizontal line through this point to where it intersects the vertical through the dry bulb temperature. Continue the horizontal line to where it intersects a vertical line through the dry bulb of 80°. On the curved lines running upward to the left will be found, by interpolation, the relative humidity of 51%.

Problem 6. Given a dry bulb of 75° and a wet bulb of 70°. Find the vapor pressure.

Draw a line through the dry bulb, 75° and locate its intersection with the diagonal wet bulb line representing 70°. Through this point draw a horizontal line to the left to Curve A, and where Curve A is intersected draw a vertical line upward to the vapor pressure Curve D. Through this intersection draw a horizontal line to the left to the vapor pressure scale and find the pressure, 0.682 in. of mercury.

Problem 7. Given a dry bulb of 65° and wet bulb of 60°. Find the relative humidity when the air is heated to a dry bulb temperature of 75° with no increase in moisture.

Locate the intersection of the vertical line through the dry bulb 65° and the diagonal line of wet bulb temperature of 60°, from which we find on the diagonal lines running upward to the right that the existing relative humidity is 75%. Through this intersection draw a horizontal line to the right to where the line intersects the vertical line through the dry bulb of 75°. On the relative

‡*This curve is not shown on the accompanying chart, but appears on the complete Psychrometric Chart obtainable in larger sizes.*

humidity lines we find, by interpolation, the percentage to be 53.5%.

Problem 8. Given a dry bulb temperature of 75°. Find the moisture in the air in grains per cubic foot of air when saturated at this temperature.

Draw a vertical line from 75° dry bulb on the lower scale to its intersection with Curve E, grains of moisture per cubic foot of saturated air. Through this intersection draw a line horizontally to the left, and find, on scale E, 9.1 grains per cu. ft. of saturated air.

Problem 9. Given a dry bulb of 50° and a relative humidity of 40%. Find the dew point, wet bulb and vapor pressure.

At the intersection of the vertical through 50° dry bulb and the relative humidity line, 50%, find on the line running obliquely down to the right the wet bulb of 40.2°. Through the intersection draw a horizontal line to the left and locate, at the intersection with Curve A, the dew point, 27°. From this intersection drop a vertical line to Curve D, and where this intersection occurs draw a horizontal line and read to the left on the scale for vapor pressure, 0.045 in. of mercury.

Problem 10. With air at 65° dry bulb temperature and saturated with moisture, find the volume in cubic feet per pound.

Draw a vertical line through the 65° dry bulb temperature on the lower scale to its intersection with Curve B, volume of one pound of dry air saturated with moisture. From this intersection draw a horizontal line to scale B at the left and read 13.5 cu. ft. per lb.

Problem 11. How much heat must be extracted to cool one pound of dry air and the moisture present under the condition from a dry bulb temperature of 85.5° and a relative humidity of 40% to a dry bulb temperature of 63.5° and a relative humidity of 83%?

(The total heat is a function of the wet bulb temperature. It does not include the sensible heat of the liquid or the latent heat of fusion and is shown as the quantity of heat above 0° F.)

Find the intersection of the 85.5° dry bulb vertical and the 40% relative humidity line. Through this intersection draw an oblique line along the wet bulb lines running diagonally upward to the left till the line intersects with Curve A, where we read the wet bulb temperature, 67.6°. Through this intersection draw a vertical to the total heat Curve C. Through this intersection draw a horizontal line to the left and read, on scale C, a total heat content of 31.5 B.t.u. Repeat this procedure for a dry bulb of 63.5° and a relative humidity of 83% and find a heat content of 26 B.t.u. Consequently the heat to be extracted will be 31.5—26.0 or 5.5 B.t.u. per lb. of dry air.

Problem 12. Given a dry bulb temperature of 75° and a wet bulb of 65°. Find the absolute humidity, or grains of moisture per cubic foot.

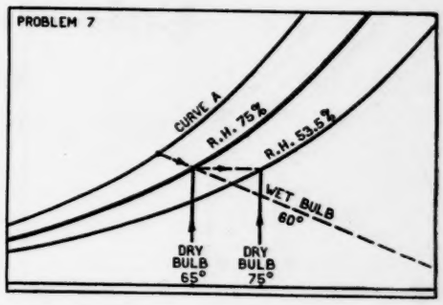
Draw a vertical line from the 75° dry bulb temperature to its intersection with Curve B, volume in cubic feet of one pound of dry air saturated with moisture, and also with the other Curve B, volume in cubic feet of one pound of dry air. From these intersections draw lines horizontally to the left and read the volumes, both dry and saturated, on scale B, the former being 13.47 and the latter 13.85. The difference between the two is the volume of the moisture necessary to saturate the air, in this case being 13.85—13.47 or 0.38 cu. ft. per lb. of dry air.

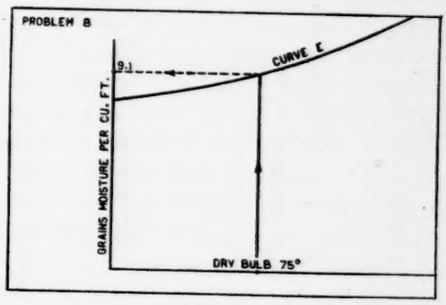
At the intersection of the 75° dry bulb and the 65° wet bulb lines the relative humidity is found to be 59%, and drawing a horizontal line through this point it is found that on extending the line to scale A, there are 76 grains of moisture in the mixture containing one pound of dry air.

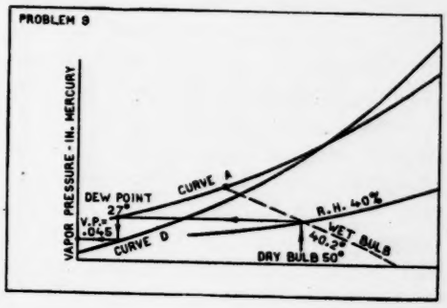
Since the volume of enough moisture to saturate the air was found to be 0.38 cu. ft., the volume of the moisture present with a relative humidity of 59% is equal to 0.59 x 0.38 or 0.224 cu. ft.

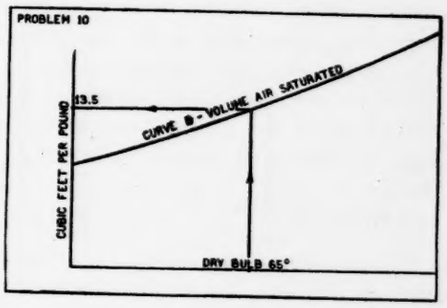
It was found above that the volume of the dry air was 13.47 cu. ft. per lb., so that by adding the volume of the moisture in the mixture to that of the dry air we obtain 13.47 plus 0.224 or 13.694 cu. ft. as the volume of the mixture containing one pound of dry air. Since there are 76 grains of moisture per pound of dry air and 13.694 cu. ft. of the mixture per pound of dry air, we have

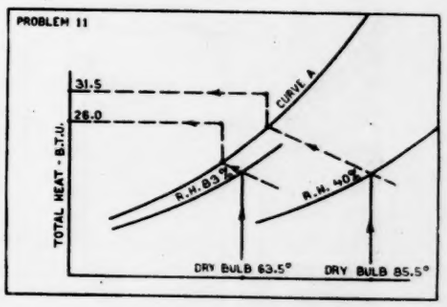
$$\frac{76}{13.694} = 5.55$$ grains of moisture per cu. ft. of the mixture.

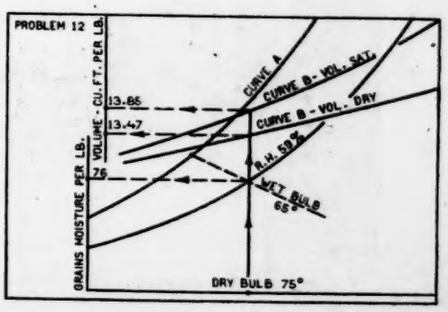












Unit Heaters as Converters for Warm Air Systems

by **R. S. Rickabaugh***

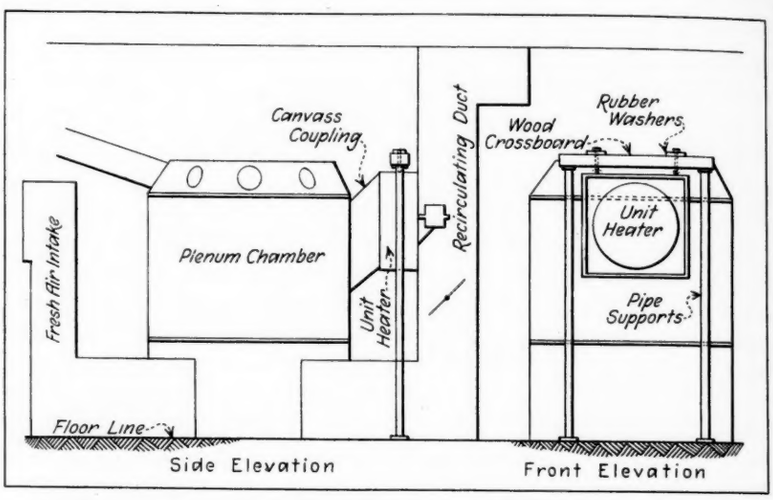
THE supplying of district steam to houses employing warm-air heating systems has long presented a problem to district heating companies in that no suitable means was available for using district steam without requiring a complete change of system, and in most cases either a preference was shown for this type of heating or the cost of changing to another type apparently unwarranted.

With the advent of the unit heater came a solution both practical and economical. It was felt that if the furnace grate could be replaced with a unit heater of equivalent B.t.u. output the system would not be changed. An experimental installation was accordingly made in the residence of one of our customers and results obtained have been most gratifying.

The B.t.u. loss for the house was computed. On this basis the unit was selected, care being taken to allow a comfortable margin of safety and to select one giving the required heat output with relatively low discharge velocity to reduce the draft and the probability of noise from air flow. Noise from vibration was overcome by mounting the unit on a cross beam suspended from the floor by two pipe supports. To further aid in reducing noise from this source the unit was suspended from rubber washers, the entire assembly being separate from the furnace casing.

In the furnace the fire box and ash pit were removed leaving only the sheet metal casing. A bottom was placed on this and a hole cut in the side of the casing. Connection to the unit heater was made by means of a canvas coupling.

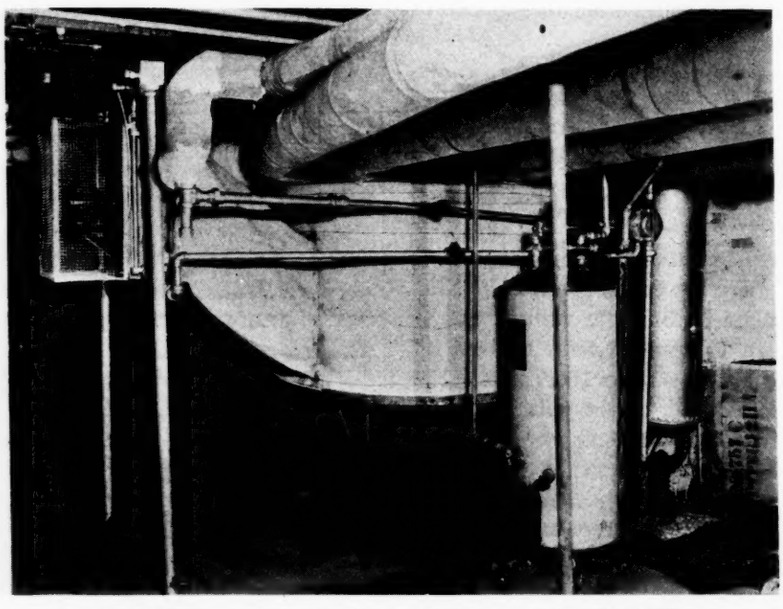
The system is controlled by means of a room thermostat controlling a fan motor. This has proved satisfactory since most heaters are designed to condense approximately only five per cent of their rated capacity without the fan, and any heat obtained from natural draft effect merely tends to lengthen the period during which the fan is not running.



Method of Connecting Unit Heater with Warm Air System

A fresh air intake and recirculating duct controlled by means of a butterfly valve, together with a humidifier, provides a constant circulation of clean air at proper humidity.

The installation described has been operating for a period exceeding a year to the entire satisfaction of both the utility and the customer. Rooms are adequately heated, there is no noticeable noise from the unit, no objectionable draft from registers, the cost of installation comparatively low, and the cost of operation right in line with other houses of the same size. With the addition of an air washer and conditioner a system such as described above will provide greater heating comfort than is possible with any other type of house-heating.



General Arrangement of Warm Air System with Unit Heater

*Steam Heat Engineer, Chester Valley Electric Co., Coatesville, Pa.

Correlation of Heat Consumption and Weather Conditions

Shown by Report of British Building Board

A correlation between the outside temperature below 65° and the heat requirements of a building has been noted by the Building Research Board of Great Britain[1], showing that the degree day is a reliable index of fuel consumption in that country as well as in our own. The board also determined the relation between outside temperature and heat requirements under rainy conditions, with sun and under various wind velocities. The studies were obtained at the Experimental House during 1928-29, the house being heated continuously with electric stoves. The heat supply was measured from 9:30 a.m. to 9:30 a.m. The report continues:

"An attempt has been made to correlate the total heat required each day in the four rooms of the house with the corresponding weather conditions.

"The average outside shade temperature affords a useful basis for the examination of the data. Values were obtained by integration of a continuous temperature record. The coefficient of correlation between the heat requirement and this temperature is computed to be 0.92.

"In Fig. 24 (Fig. 1) the heat requirement is plotted as a function of the average temperature, the observations being grouped in intervals of 3½° F. The number of observations in each group is shown. From the graph the heat required is 4.14 (65-T) kw.-hr. per day, where T is the average temperature. It is of interest to compare this with the value computed in the normal way for an inside temperature of 65° F. and half an air change per hour. Assuming values of K, for 9-in. brick walls (plastered internally) 0.36, for glass 1.00, for the roof, 0.25, and neglecting loss through the floor, the calculated requirement is 4.24 (65-T) kw.-hr. per day.

"Sunshine affects both the heat requirement and the average outside temperature. In the analysis of the data the problem is not so much 'how does sunshine affect the heat requirement?' as 'how does the heat requirement computed from the average temperature agree with observations on sunny days?' In Fig. 25 (Fig. 2) the observations for the days with more than three hours of sunshine are grouped and plotted together with the straight line of Fig. 24. It is clear that the heat computed from the average temperature tends to be in excess of the actual requirement on sunny days.

"Fig. 26 (Fig. 3) in similar manner shows that the heat computed from the average temperature tends to be less than the actual requirement on rainy days. Fig. 27 (Fig. 4) illustrates that wind increases the heat requirement, particularly in cold weather. When due allowance is made for the effect of sunshine, rain and wind, the correlation between heat requirement and average temperature is computed to be 0.994. This high value indicates that it is unnecessary to consider other meteorological data, and that, for the method of heating employed, the daily heat requirement of the house is determined when the average temperature and amounts of sunshine, rain and wind are known.

"During the present season the heat requirements of the house are being studied when its rooms are warmed continuously by radiant heaters in place of the convective heaters previously used. Two types of heaters are used. With the data collected it is hoped to extend the statistical investigation of meteorological influences outlined above.

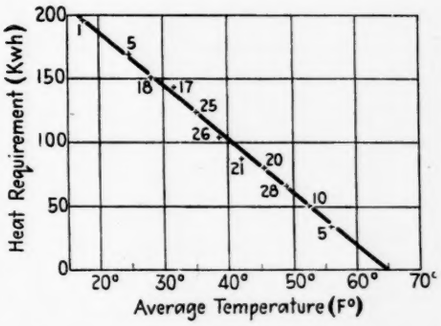


Fig. 1. Relation Between Heat Requirement of a House and Outside Average Temperature

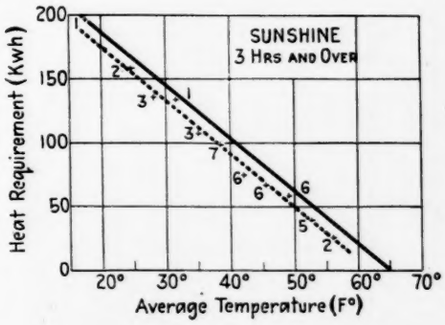


Fig. 2. Effects of Sunshine on Heat Requirement of a House

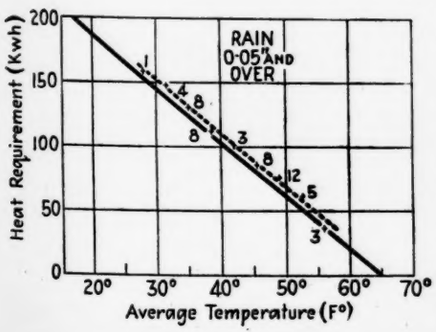


Fig. 3. Effect of Rain on Heat Requirement of a House

[1] *See pages 81-84, "The Report of the Building Research Board for 1929," published by His Majesty's Stationery Office for the Department of Scientific and Industrial Research, 16 Old Queen St., Westminster, S.W.1. Price 2s. 6d.*

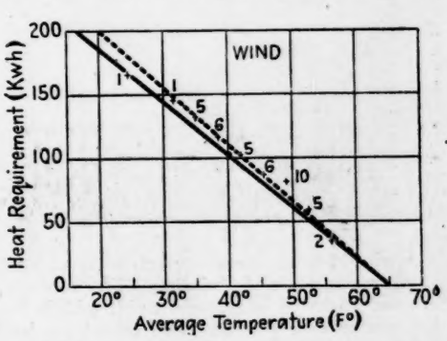


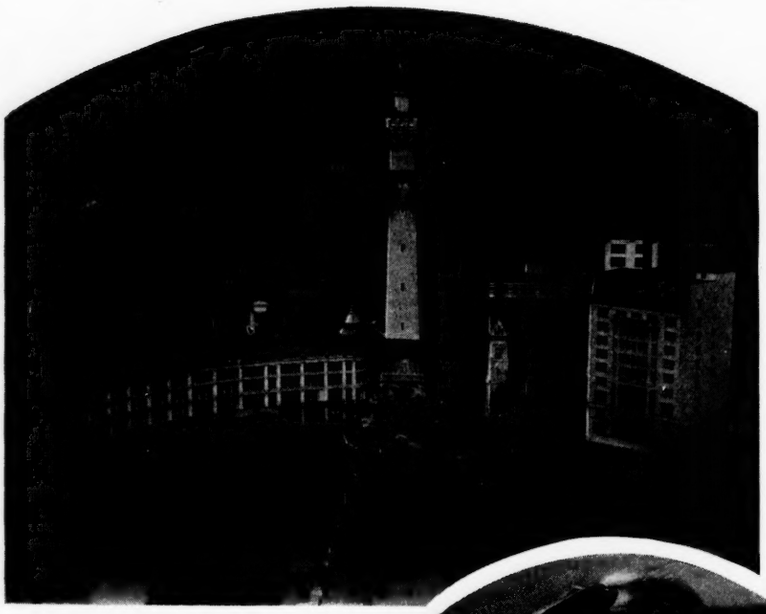
Fig. 4. Effect of Wind on Heat Requirement of a House

Fighting AIR

IT is not generally realized that air pollution from smoke and dust has assumed such alarming proportions that 13 cities have made dust counts extending over a period of a year and are now, through the cooperation of health authorities, studying the results.

With every breath we inhale a million microsticks and a host of other things which are not a part of the pure atmosphere. These tiny particles represent fragments of vegetable fiber, pollen of conifers, ragweed and a thousand other trees and plants, the dust from active volcanoes and the ashes of meteors and tiny stars. The smoke thrown off by heating and industrial plants is fil'ed with soot. This smoke is responsible for foggy conditions in the atmosphere, and serves as a blanket shutting off the ultra violet rays of the sun.

The Department of Health of the City of New York is making records of the air pollution in that city. An instrument, called the Owens automatic air filter, is

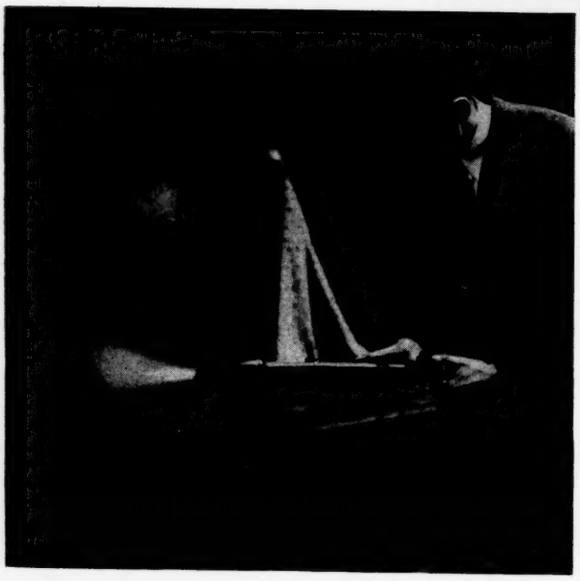


A view of Monument Circle, Indianapolis, showing the pall of smoke hanging over the city on a smoky day.

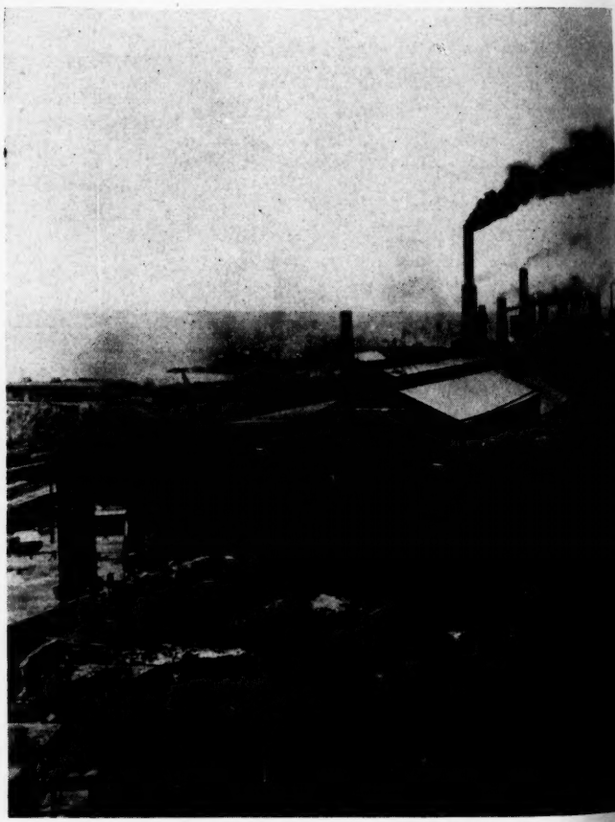
An inspector using the "Umbrascope" to determine the density of smoke.

The factory district of East Cleveland doing its share toward increasing the smoke nuisance.

Photos by



A high-pressure steam gun used to clean the exterior of a smoke stained building. The chemical used is a diluted form of sulphuric acid, which is mixed with hot water and steam. The effect on health, loss of light and necessity of constant cleaning amount to $16 per capita in New York State.

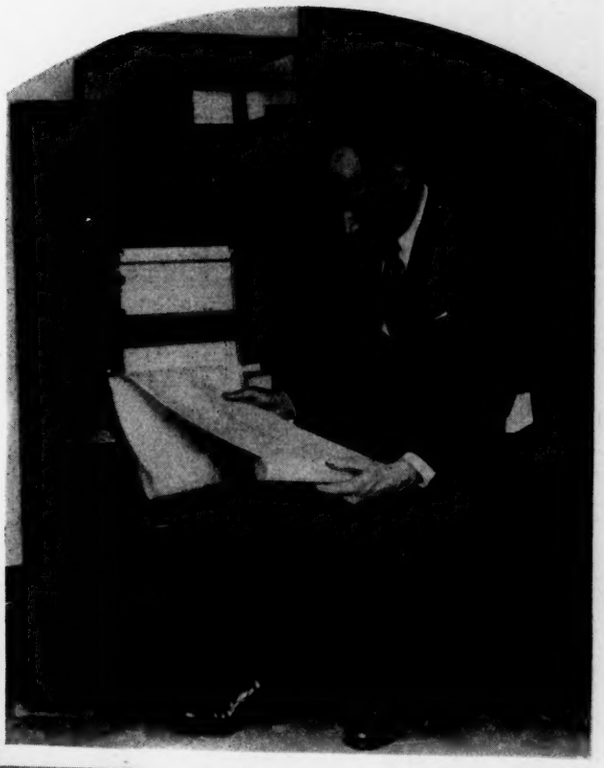


POLLUTION

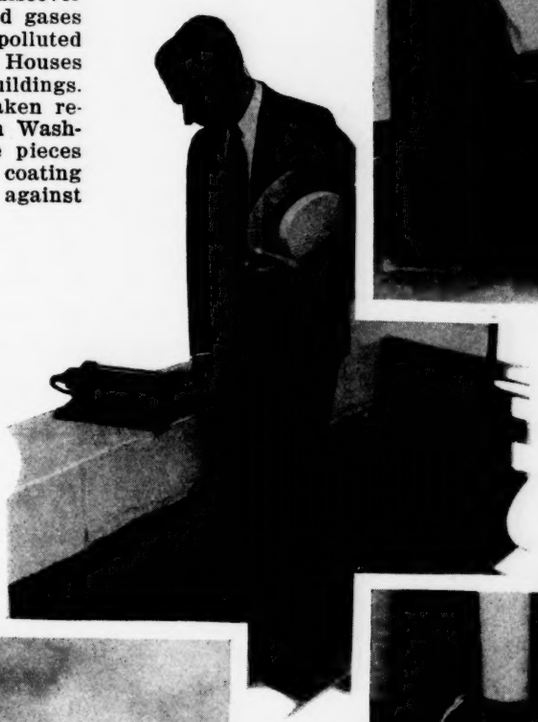
used to keep a continuous record of the air pollution throughout the entire 48 hours of the day.

It was found that during the month of January the air was purest at four o'clock in the morning and dirtiest five hours later at nine o'clock. This was explained by the fact that after four o'clock janitors begin to fire the boilers in apartments and office buildings, and nine o'clock finds them running full blast.

The Owens air filter was invented ten years ago by an English engineer and has been used in England to discover the source of the smoke, dirt and gases in the air. It is said that the polluted air is crumbling the stone in the Houses of Parliament and other old buildings. In New York City steps were taken recently to protect the Cloisters on Washington Heights where many fine pieces of Gothic art are displayed, by coating the exposed marble to protect it against the corroding gases in the air.

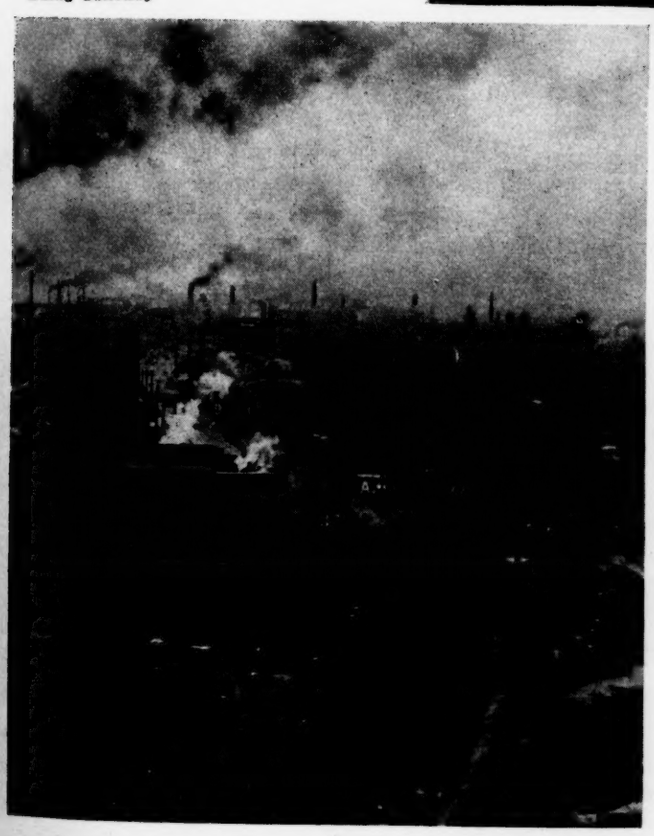


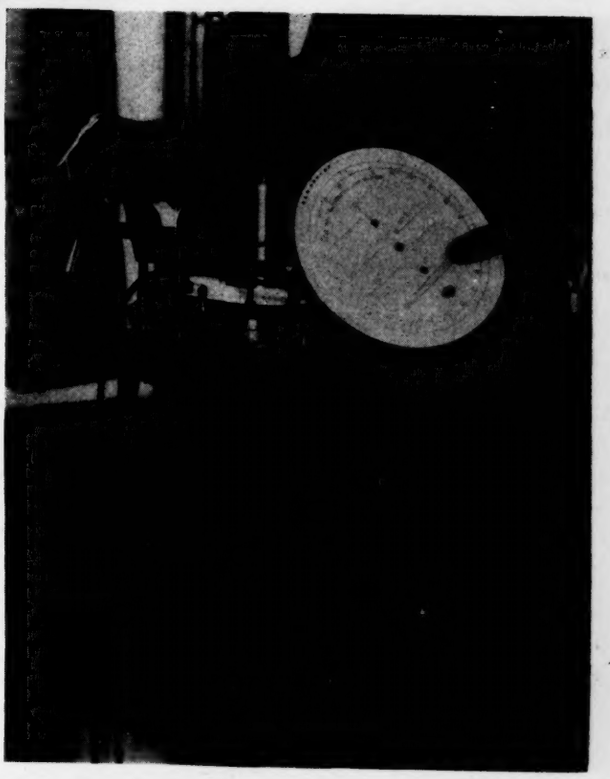
The Potentiometer recording the results from the "Electric Eye." One day's record is from 3 to 4 ft. long.



Commissioner Wynne of the New York Department of Health examining the "Electric Eye," an instrument which automatically keeps a record of the city's smoke

Ewing Galloway





This filter disk on the machine on which air pollution is recorded. The small rubber tube is hung on the outside of the window and through it the air is drawn through the paper filter disc, leaving dark smudges on the edge of the disc which are later compared with a scale of standard shades.

Ewing Galloway

There is a Lot of Misunderstanding about Quantity Production. The Principles Cannot Necessarily be Applied to the Contracting Business

How Much More TALK?

***by* William E. Taylor**

I think that almost any human problem can be solved if those interested in it will come together in one room and talk it over.—Herbert Hoover

TALK is necessary to reach a conclusion, but if nothing follows except more talk in useless effort to please everybody, then even the talk stops, except the kind that takes place after a meeting among those who had nothing to say where it might do some good, but who hold forth lustily on the street corner with a solution for every problem. That is, for every problem except the one of getting others to agree.

Talk all you want to, but when you have finished, *do something.*

The concentration of administrative powers through the process of creating holding companies, mergers, chain stores, chain banks, and department stores is the expression of mature business judgment on this question of talk. It is an effort to procure efficiency to replace the discouraging and destructive results which follow in the wake of individualism and its mouthpiece —unrestrained competition.

In the end, these aggregations of capital will grow to such size and power that it will be found necessary to select certain of them, in which the protection of the public interest seems necessary, for regulation. It will be found that the Federal Government is the only interest large enough to cope with them.

We profess to believe that the finger of government in business is not good. Why, then, isn't it plain common sense to prevent that eventuality by taking the principle involved in that type of business organization and putting it to work by delegating powers and centralizing responsibility in associated group activity?

It has been my observation that hired management is good management with standards of ethical conduct parallel to the best of professions. It approaches business problems with more of impersonal interest and less of prejudice.

It is peculiarly adapted to the trade association form of business organization with all the advantages of merger organization and none of the arrogance and abuse of power.

It is not easy to find the man to run it, but when he is found the full responsibility and authority should be placed with him for a definite time.

It will be necessary for the group itself to be committed for at least the same period and the financial program insured against withdrawal. Too often this is not properly cared for and there is so much backward movement that all forward movement is nullified. The executive will endeavor to find out what the members are thinking about and when he reaches the end of that endeavor there will be just one unanimous dissatisfaction—Profit.

The reasons, the individual responsibility and any other contributing causes of the chaos do not interest the contractor in the least. He wants profit. Profit at once if not sooner, without any requirement from him which will restrict his freedom of action in any way.

Those who are in a hurry are a serious obstacle to

accomplishment by those who are willing to take time to do the necessary serious work.

Analysis of the problem of profit leads naturally to the question of costs; not so much the direct cost of material, which, in the large view, is a matter of accuracy in tabulating quantities and adding together quotations made by suppliers, but more particularly, labor costs and the general expenses of organization and operation classified as overhead costs.

Most of the juggling is done with these last two elements.

Contrary to the adage that figures don't lie, they are the biggest liars in the world when handled by liars, for of course it is simple to make up figures to show any desired result and it is particularly simple when making an estimate sheet.

When experience and intelligence indicate that the figures used are false, it would seem to be nothing short of business suicide to use them, but it isn't quite as simple as that where unrestrained and irresponsible competition has full sway.

In the long run, a willingness to quote a too low price will discount the best in organization and experience and profitless prices become a necessity and practice to keep organization together waiting for the time when those who are financially weak die off or some miracle happens which will permit better profit.

It is this do-nothing, waiting-for-something-to-happen period which should be the time of greatest association activity in collecting and constantly distributing facts and building ethics and morale.

Keeping everlastingly at it, rain or shine, is the watchword and, as I have made clear in a previous article, success is possible in proportion as the membership of the group numerically represents the industry.

There are too many who simply don't know the facts and who try to operate on the basis of what some one told them or the misapplication of some fact from another type of business.

For instance, there is a lot of misunderstanding abroad about quantity production and its influence upon overhead costs in manufacturing establishments, which the contractor attempts to apply through increased volume of business, assuming that increasing the total amount of his contracts in dollars has the same effect as the increase in number of automobiles made would mean to the manufacturer, and he gives away this assumed reduction in cost in order to get the greater volume.

Each heating system is tailor made for the building in which it is installed and mass-production methods are, in all essentials, impossible of application. Overhead costs vary on each contract, influenced by location of the work, transportation and supervision, and no two jobs are alike in all factors.

In a manufacturing business the organization is highly developed and specialized, the factors are more nearly constant and the influence of quantity upon cost can be accurately predetermined.

I made a survey of overhead costs in the contracting business in 1928 covering records from nearly 5000 firms in the heating business distributed well over the entire country and it was clearly shown that average overhead costs and overhead costs on individual jobs are two very different subjects.

A contractor with a volume of $1,000,000 may show an average overhead of about 10% but the overhead chargeable to the average size of contract he takes will be nearer 20%.

I know how easy it is to cheat the overhead and how generally this practice prevails. Don't fool yourself if it is not shown as overhead. It is there just the same, no matter what you call it.

I haven't told a story yet, so perhaps I may be pardoned if I tell one, although it is very ancient, but it fits this situation.

A salesman lost his hat and bought a new one, charging it up in his expense account. The item was promptly disapproved and a letter was sent informing him that it was not a proper charge against the business. The salesman evidently accepted the situation, for subsequent expense accounts appeared to be in order.

When he came in one day the boss remarked "I don't see any more hats in your expense accounts," and the salesman replied "No, you can't see it, but it is there just the same."

It's like that with overhead, and the process of a contractor being estimator, bookkeeper, telephone operator, truckman, laborer, credit man, collector, paymaster, hirer and firer of labor, is not reducing overhead. It is just giving something for nothing and yourself a headache.

The accompanying chart tells the story of legitimate average overhead based on volume at the end of the year and if worked in the opposite direction will indicate approximate and safe overhead charges on a contract of given size.

In the face of these figures, will some one explain how a contractor operating on the basis of 3% to 8% gross, including profit and overhead, can expect to show a profit. And furthermore, if he hasn't any cash capital what does he use for money? The answer is bills payable but not paid.

Mr. Good Business Man, you know that this is true but even you make figures lie because you have to do it to get business. Wouldn't it be wiser for you to reach out into the office of the Poor Business Man through your organization and teach him the right way?

The process of waiting for him to go into bankruptcy does not help you and takes too long anyway.

Think it over, talk about it and then Do Something.

I said earlier in this article that the cost of material is largely a matter of accuracy in tabulating quantities and adding together quotations, but I did not mean that it was so simple and easy that it had no influence in the making of too low prices.

It is a peculiar fact that nine times out of ten when an error is made in material, the quantity is less than it should be. Hardly ever in the contractor's favor, but as a rule against him. It is also a peculiar fact that every contractor thinks that his estimate is right and all others are wrong.

As a matter of fact some are very accurate as a rule but most of them are very inaccurate and careless in making estimates. Even the best of them slip once in a while and when they do, it sometimes is a serious

matter, involving the difference between a profit and a serious loss. Whole floors of radiation and equipment have been omitted due perhaps to the frequency of using one drawing of typical floor plan for many stories of a modern building.

There is always a reason of course but that won't help much when red ink appears, and anyone who is familiar with the working conditions in a contractor's office will know that only a small fraction of the reasons for error in making estimates are recognized.

The estimator is a general utility man in the office and on the job. He sits at his work table with the plans and specifications before him taking off material. He is constantly interrupted by telephone calls, visits from salesmen, dropping the work to supervise work in progress outside and must start in where he left off when interrupted and make no mistakes.

In the better organized offices most of this interruption is stopped because the estimators are not accessible to salesmen. They are tucked away in a quiet section of the office. They less often answer the telephone and have a better chance to concentrate and be accurate.

The great mass of contractors maintain the conditions first pictured and it is a temptation to think that if they make a mistake they pay for it. Why worry about it?

If it did no other harm, if the contractor who makes the error was the only one hurt, there would be some excuse for taking that attitude. But when it is shown that such conditions are a direct contribution to the general conditions of chaos and profitless prices, it becomes a matter that is the personal business of every contractor and the bigger he is in business, the more important it becomes.

I also made the statement earlier in this article that "In the long run willingness to quote a too low price will discount the best in organization and experience and profitless prices become a necessity and practice, to keep organization together, etc." and I had in mind the fact that in the final analysis it makes no difference what the reason for a too low price may be, whether an error in estimating or juggling overhead and profit, the net result is a price that is too low. It damages the contractor who makes it and every other contractor in the trade, because others will accept it as a new low level of price at which they must shoot the next time and thus the toboggan is built.

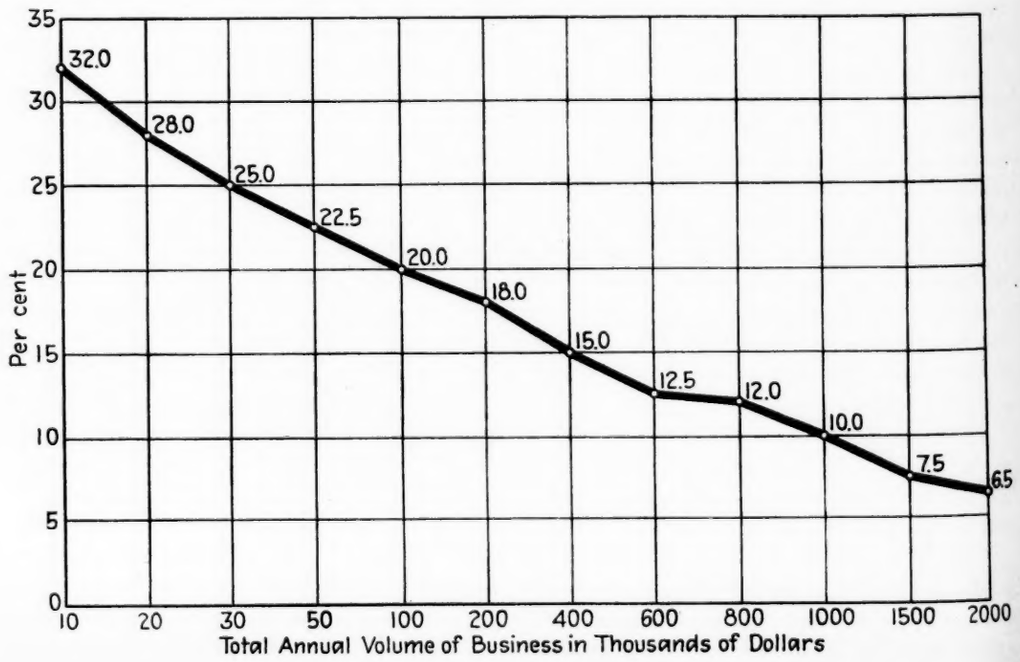
It does not matter today how long you have been established, your reputation, your experience, your capital—when you are bidding in competition, the prices arrived at by shooting at constantly decreasing levels of price are actually the yard stick you use in making your quotation.

Can you therefore believe, much less say and try to maintain, that it is not your business how your competitor operates his business?

The man who will confess that he wants to destroy for those who come after is the only one who can justify such an attitude no matter what success is behind him. The processes of interpreting the requirements of specifications uniformly, establishing uniform quantities of material required to meet those specifications for purposes of estimating cost and if the plans and specifications are wrong, someone pays other than the contractor. Educating the ignorant regarding overhead and profit and planting principle and ethics where nothing grew before, are distinctly the business of those engaged and expecting to stay in a trade and the cost of doing it a legitimate charge on the industry.

The Quantity Survey Bureau is no longer an experiment and it is a necessary component part of any plan likely to succeed in making the heating contractor's business profitable and a business which develops those engaged in it to higher ethical levels than has been the case for too long already.

All material quantities should be guaranteed by the bureau and absolute protection in this respect given to the contractor. Through the development of understanding with architects, consulting engineers, general contractors and owners, all of whom will appreciate the service which can be rendered, such a bureau will do much to strengthen better relations between competitors in a trade and all who use their services.



Average Overhead Based on the Volume of Business Done Per Year

Mulhearn and Cassidy Discuss Architecture as a Profession

With Apologies to "Mr. Dooley"

***by* "Waddy"**

MR. Michael Mulhearn came down the street one evening recently on his way to attend a meeting of the "Best People on Earth." It was to be a special meeting in honor of Past Exalted Ruler, Jack McGuire, followed by an entertainment such as the "Best People" frequently enjoy. Passing Cassidy's Electric Shop, and seeing his friend and fraternal Brother inside, Mulhearn entered.

"Hello, Cassidy!" sez Mulhearn. "Are ye goin' over t' th' Ilks tonight? It's McGuire's Night ye know. All the Tads will be there, an' it'll be some party."

"Be Gorry, Oi'd like t' go, Mike, but Oi gotta git out th' istimate on this dommed apartmint house Oi'm figgerin' out o' Bunkum and Blah's office. Th' bids are due at tin o'clock in th' marnin' on th' steenth o' Dicimbur, which is tomorry, in this year of our Lord, 1930, whin they will be opened an' read."

"But why all th' drawin' ye are makin' Cassidy? I thot th' archeetickt got paid fer thot."

"Shure he does, but he don't do it. We hafta do it fur him. Bein' an archeetickt is th' graandist racket in th' wurrld, Mike, if ye only have th' eddicashun t' be wan. Jist take a peek at thim spicificaashuns, Mike, an' read where it sez:

"'Th' Conthrathor shall submit plans in duplikit fur th' entoire system av wirin' fur th' archeetickt's approval. Archeetickts will keep wan sit of these plans in their office fur rifirince.'"

"That means that Oi gotta make th' plans, Mike, that th' archeetickt gits paid fur makin. Av coorse, Oi gotta charge fur me ingineerin' skill, but Oi jist add it in me figger, an' th' owner don't know th' diffurnce. Read th' rist av it, Avick, it's grate stuff."

"'Th' conthrathor shall submit skidule av all wirin' sizes, make av same, an' plan av instillation fur th' intoire buildin.'"

"An' thin down there it sez, 'All wires are t' be av copper.' Oi wunder if they think th' Underwrithers' Inspictors wuld stand fur iron. An' ye notice they don't say a wurrd about th' grade av wire, ixcipt that it shall be rubber covered, double braided; so we figir th' cheapist th' Inspictor will pass.

"Most av th' things they minshun are things we hafta do annyhow. Here it sez, 'Conduits must be av such size as t' permit th' riddy insertshun an' withdrawal av th' wirin'. That's a lot av hooey, cuz th' Code tells ye whut size pipe ye gotta use fur diffurent sizes av wire. They're like that all thru—whut they shulld tell ye, they don't, an' whut they do tell ye, don't mean nothin.

"Oi wuz talkin' t' O'Brien to-day—he's figgerin' th' plummin' an' heatin—he sez his Spicificashuns reads like this—

"'This Conthracktor must make, or have a compitint Ingineer make a drawin' av all sewers, waste lines, drains, vints and leaders, showin' th' sizes av th' various branches, an' th' fixtoores to which th' waste lines are connicted.

"'Two blueprint copies must be filed with th' archeetickt before th' date ordered fur th' beginnin' av th' wurrk, an' wan o' these copies must bear th' offichul O.K. av th' Chief Plummin' Inspictor av th' City.'"

"O'Brien sez th' heatin' ain't so bad. It wuz laid out by wan av thim heatin' spicilty firms that does free ingineerin', an' thin stick fifty cints on t' th' cost av each valve an' thrap so's t' covir th' cost av it.

"Mike, if Oi had a son, Oi'd make an archeetickt av him. Ye see they git six percint av th' total cost av th' job fur makin' plans, writin' some bunk, an' thin watchin' us build it.

"Av course, there are some very high grade archeetickts who have ingineers assochiated wid thim, an' make complete plans an' spicificashuns like they are paid fer doin'. Tis not thim kind O'm spakin' av. Some firms do iligant wurrk.

"But some others jist make some pretty pictoors. Thin they git some steel company t' desighn th' steel fur nothin'. Av coorse th' steel people load up th' tonnage t' git ther pay fur it.

"Thin th' heatin' supply man lays out th' heatin' system fur t' git spicified, an' adds a dollar a radiatur t' git his pay.

"Thin th' plummer has t' hire a ingineer to lay out th' plummin' an' he has t' bury th' cost some place t' git out from under.

"An' us fellows has to lay out th' wirin' an' thin bid th' job.

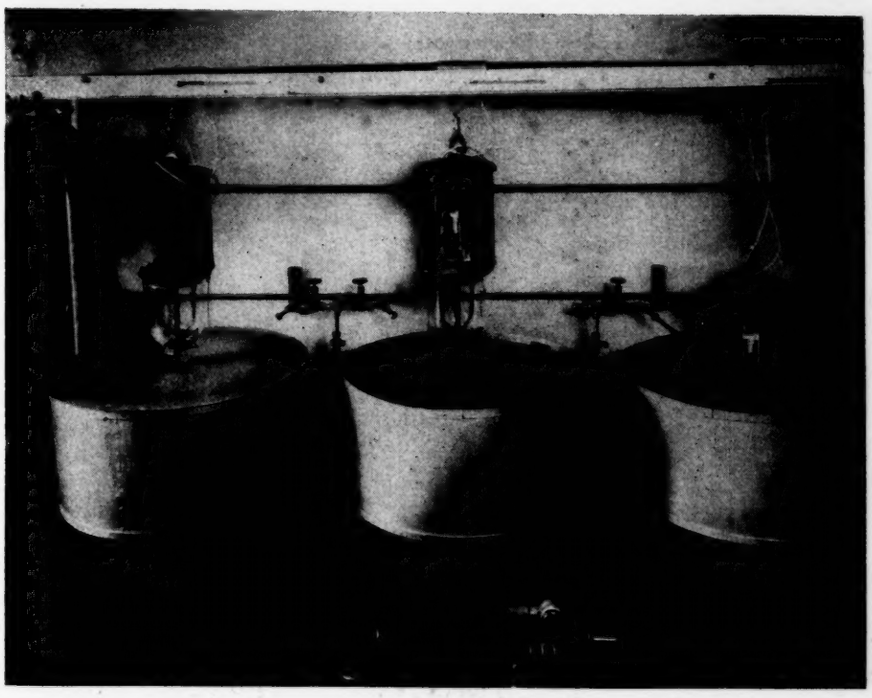
"Where do we git ours? Oh, we cover some av it in our bid, an' hook th' owner fur th' rist in extrays, fur stuff th' archeetickt fergits t' put in, er things he don't know. They's thricks t' all thrades ye know.

"So ye see, Mike, what a graand racket i' tis. Th' owner pays twice, an' so long as he don't know it, he's happy. An' th' archeetickt draws six percint fer doin' wurrk worth about one percint."

"But, Cassidy, that's jist th' same as stealin."

"Shure, Oi know i' tis Mike, only it's legal, an' ye can't do nawthin' about it. It's got bootleggin' skun a mile. Oi till ye, Mulhearn, archeetickure is a graand perfeshun.

"Well, so long, Mike, sorry Oi can't go t' th' Ilks wid ye. Maybe Oi'll be over later fur th' intertainmint."



United States Bureau of Standards

Creating Artificial Weather

The United States Bureau of Standards determines effect of long exposure of structural materials to the elements without having to wait for long periods of time to elapse, the "weathering machine" shown above being employed. Slats for holding samples of the tested materials are shown in the uncovered tank at the right. An arc lamp, a rotating lawn sprinkler and refrigeration equipment are used to produce effects simulating those caused by sunlight, rainfall and changes in temperature.

Abstracts . . .

Reviews and Summaries of Current Papers, Books and Pamphlets

Handbook of Oil Burning

by **Harry F. Tapp**

Published by the American Oil Burner Association, 628 pages, profusely illustrated, 4½ in. x 7½ in., cloth or flexible binding. Obtainable through the association at 342 Madison Ave., New York. Price, $2.50 to $4.50, depending on binding and membership.

THE book brings together much information and data not only on technique but on sales and service methods and accounting as well. In fact, virtually every phase of oil burning whether domestic, commercial or industrial is at least touched upon. While frankly intended to state the case for oil, the competing fuels and some of their properties come in for mention. In the main, the subject of comparative values of fuels is handled in a straightforward fashion without undue bias. The book certainly should prove of immense value. To an industry which has so long been without a comprehensively prepared book for its own uses, this one should be especially welcome.

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Investigation of Various Factors Affecting the Heating of Rooms with Direct Steam Radiators

by **Arthur C. Willard, Alonzo P. Kratz, Maurice K. Fahnestock** *and* **Seichi Konzo**

Bulletin No. 223 of the Engineering Experiment Station of the University of Illinois, 104 pages, well illustrated. Obtainable by addressing the station at Urbana, Ill. Price, 55c.

THE third of a series of bulletins reporting the results of studies on steam and hot water heating systems. Among others, the factors studied and here reported include: Location of radiator in the room; enclosures, shields and covers; kind of paint used; storm sash and doors; window shades and curtains, and a special study of surface temperatures and temperature gradients through walls and glass.

Tests were made both in specially constructed test rooms and in rooms in a building. The test rooms permitted controlled conditions while the other rooms served to provide conditions permitting testing under the influence of actual weather.

The tests reported cover such a variety of factors that the average reader would not be able or willing to follow the details of the tests and the conclusions drawn, were it not for the extremely clear way in which the data are presented and analyzed. As it is, the bulletin is so valuable that everyone interested in heating should be in possession of a copy.

The actual conclusions reached are undoubtedly of value, but one of the indirect results of these studies is the increased attention which the data are causing to be directed toward the subject of surface temperatures. Concerning this the report reads:

"Inasmuch as it is customary to use the temperature at the breathing level as an index of the comfort of the occupants of a room, this reduction in the temperature of the inside surface of the wall with increasingly unfavorable outdoor conditions assumes an importance outside of the fact that the heat loss from the room also increases with these same unfavorable conditions. The occupant of a room is subjected to the radiant effect of the walls of the room. Any reduction in the surface temperature of the walls increases the heat loss from the body and may result in a feeling of chilliness, even though the temperature of the air in the room is 70° F. or above. Thus, if the occupants were just comfortable when the outdoor temperature was 45° F. and the temperature of the inside surface of the wall was 67° F. they would not be as comfortable when the outdoor temperature dropped to —2.5° F. and lowered the surface temperature to 60° F. They would probably be decidedly uncomfortable if an additional air movement now further reduced the inside surface temperature to 54° F. as previously indicated. An additional difficulty also becomes evident, since for any given heating unit the temperature difference between the floor and the breathing level also increases with decreasing outdoor temperatures, and a reduction in the temperature of the air near the floor will inevitably accompany the reduction in wall surface temperature. Hence, the indication of an air temperature of 70° F., or higher, at the breathing level may not be a true criterion of the comfort of the occupants, and assertions of discomfort may be entirely justified. This may naturally result in too much emphasis being directed toward condemnation of the heating plant, rather than toward conditions external to the plant itself.

"Since, for a given outdoor temperature, the temperature of the inside surface of the wall is also dependent on the type of wall construction, the poorer types from the standpoint of heat transmission giving the lower inside surface temperatures, the conditions discussed serve to emphasize the necessity for adequate wall construction, particularly in the colder climates and in those with prevailing high winds. Furthermore, the results indicate that extra heat insulation for walls may have a value in addition to whatever saving may be effected by reducing the heat transmission, in that the use of such insulation results in higher temperatures for the inside surfaces of the wall thus protected. The latter condition will be directly reflected in an increase in comfort with a given temperature at the breathing level."

The following conclusions are listed:

(1) The steam condensation of a direct cast iron radiator, expressed in pounds of condensate, is not an adequate measure of the performance of the radiator. The heating effect produced on the air in the room must be taken into consideration in making comparisons between different types of radiators.

(2) Long, low, thin cast iron radiators placed under windows heat a room more comfortably and more economically than higher column or tubular radiators similarly placed.

(3) Long, low, thin cast iron radiators maintain mate-

Copies of papers or books abstracted on these pages should be ordered direct from the publishers.

rially better floor to ceiling temperature differentials than high column or tubular radiators.

(4) The larger portion of the temperature differential in a room heated with direct steam cast iron radiators of the column and tubular types occurs between the floor and the breathing level.

(5) The temperature used as an indication of whether a room is properly heated or not should be observed at some level nearer the floor than the breathing level. The 30-in. level is tentatively suggested as more representative of conditions in the zone of human occupancy.

(6) The use of a properly designed enclosure or shield on a tubular or column type of radiator results in a gain in steam economy, and equally or more satisfactory air temperature conditions in the room as compared with those obtained by the use of the same radiator unenclosed.

(7) The use of an improperly designed enclosure on a tubular or column type of radiator results in a reduction in steam condensation and in unsatisfactory air temperature conditions in the room as compared with those obtained by the use of the same radiator unenclosed.

(8) The condition mentioned in conclusion (7) may be partly corrected by sufficiently increasing the size of the enclosure and radiator. It is possible to obtain practically as satisfactory room temperature conditions as those obtained with the smaller unenclosed radiator, and slightly greater steam economy.

(9) A properly designed enclosure or shield should offer a minimum of resistance to the flow of air over the radiator under gravity head, and should protect the wall back of the radiator against the effect of direct radiation from the radiator. It should have the top of the opening in the face of the enclosure as high as possible, and permit free access of air over the lower half of the radiator, especially near the floor.

(10) No material gain in economy or room temperature conditions may be realized from the use of an enclosure or shield on a wall type of radiator.

(11) Increasing the size of an enclosed or an unenclosed radiator results in a uniform increase in the room temperature at all levels in the room, and an increase in the steam condensation. The steam condensation, however, increases at a greater rate than the increase in indoor-outdoor temperature difference, and it is not safe to predict the steam condensation for one size of radiator from the room temperature gradient curves and steam condensation for another size.

(12) Both steam condensation and room air temperature conditions are affected by the location of the heating unit. In general the location under a window in the exposed wall is to be preferred to a location near an unexposed or warm wall.

(13) The location near the ceiling is a most unfavorable location for a radiator and is not to be recommended.

(14) Painting a radiator or enclosure with an oil paint, irrespective of the color of the paint, has no material effect on the heat transmission as compared with that for foundry finish or oxidized iron.

(15) Galvanizing or painting with metallic bronze paint reduces the heat transmission from an enclosed or unenclosed radiator below that obtained with oil paint. The reduction is approximately 9% in the case of unenclosed tubular or column radiators.

(16) The use of an enclosure having clearance between the radiator and the back of the enclosure reduces the temperature of the wall surface back of the radiator approximately 45° F. below that obtained with an unenclosed radiator.

(17) The use of an enclosure with a galvanized back, or one painted with metallic bronze paint, reduces the temperature of the wall surface back of the enclosure from 10° to 25° F. below that obtained with an enclosure with the back painted with oil paint. In this respect galvanizing is slightly more effective than gold or aluminum bronze.

(18) The use of storm sash alone does not materially affect the room air temperature conditions, but did effect a gain in steam economy of approximately 11% in the particular room tested.

(19) The use of a storm door alone improves room air temperature conditions, and in the particular room tested effected a gain in steam economy of approximately 21%.

(20) The use of both storm door and storm sash improves room air temperature conditions and in the particular room tested effected a gain in steam economy of 31.7%. The actual saving in general will be dependent on the ratio of window and door area to exposed wall area, and on the air-tightness of the storm door and sash.

(21) Variations in basement and attic temperatures do not have a material effect on room air temperature conditions.

(22) Variations in the amount and arrangement of the exposed walls may have a very material influence on both room air temperature conditions and steam economy.

(23) The degree of comfort experienced by the occupants of a room is greatly influenced by the temperature of the inner surface of the walls as well as by the temperature of the air in the room.

(24) The temperature of the inside surface of exposed standard frame walls varies from 67° to 59° F. for walls not exposed to air movement, and from 65° to 53° F. for walls exposed to an air movement of approximately 10 miles per hour as the outdoor temperature ranges from 40° to —10° F. and the indoor temperature remains constant at 72.5° F.

(25) The temperature of the inside surface of single pane glass without storm sash, and with an outdoor temperature of —2° F., is approximately 33° F. when not exposed to air movement and 17.5° F. when exposed to air movement of approximately 10 miles per hour.

(26) The temperature of the inside surface of the inside glass pane when storm sash is used and with an outdoor temperature of —2° F., is approximately 52° F. when not exposed to air movement and 41° F. when exposed to air movement of approximately 10 miles per hour.

(27) The use of curtains and shades does not materially affect the room air temperature conditions and steam economy, but does serve to increase the degree of comfort of the occupants by shielding them from radiation to the cold glass surfaces.

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Air Conditioning in the Bakery

by **W. L. Fleisher**

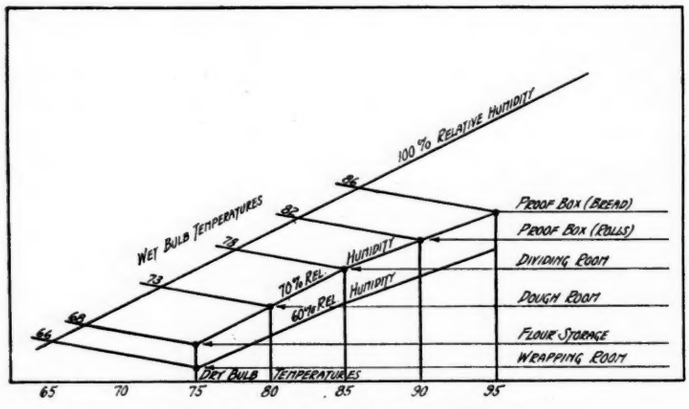
A.S.H.V.E. paper, annual meeting January, 1931. About 5000 words, 6 charts, 1 table, 4 photos.

A THOROUGH discussion of the principles of bread-baking, including a statement of the chemical and physical changes involved in the process, and the author's conception of the relation and importance of air conditioning thereto.

The hydration process present in modern machine bread-baking is believed to be a surface condition since the author calls attention to the fact that the total moisture changes throughout the whole process are not relatively great.

The theory and application of the hydrogen-ion concentration and its effect on the starch, the gluten, and the fermentation is presented at some length.

An interesting psychrometric chart is included in the paper. The author feels that the maintenance of closely processed air in the flour storage room is of minor importance. He states that "From the flour storage to the fermentation room, there is no question that temperature is the determining factor, and this temperature is maintained solely with the idea of regulating the rate of fermentation." Moreover, he believes that if the means used to introduce the air into the dough rooms could be so arranged that air at high velocity would not strike directly on the dough, probably lower relative humidities than now used could produce satisfactory results.



Psychrometric Chart for Bakeries

The final proofing of the bread in a special box is widely practiced. The maintenance of definite conditions in this room allows all the pans to develop in the same length of time and greatly facilitates the orderly timing of the baking.

The author suggests that careful study should be given to the important underlying phenomena involved.

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Air Conditioning with Ice in Motion Picture Theatres

by **J. F. Dailey**

Paper presented at meeting of the Louisiana-Mississippi Ice Association, Jackson, Miss., January, 1931.

THE author advocates the use of ice for cooling the spray water instead of using an isolated mechanical refrigeration plant installed on the premises.

The exact details of the method are not stated but from a sketch it appears that the cooling water would pass over ice in an ice bunker, would collect in the bottom and be pumped through the sprays. Apparently, the plan would provide for recirculating some of the air on the hottest days.

The author describes an experience of his in using his plan in the Rivoli Theater in Baltimore. In connection with this installation he sets up the following table to uphold his contention that ice is to be preferred to the use of mechanical refrigeration:

		Cost of Mechanical Refrigeration $40,000	Cost of Ice Cooling Comb-System $14,000
Interest per day	$2400 for 100 days	$24.00	$840 for 100 days — $ 8.40
Depreciation per day	$4000 for 100 days	40.00	$1400 for 100 days — 14.00
Hire of engineers per day	2 @ $10	20.00	None
Power required per day	180 kw.-hr. @ 4c x 10 hr.	72.00	35 kw.-hr. @ 4c x 10 hr. — 14.00
Refrigerant per day		2.00	None
Ice per day		None	22 tons @ $4 per ton — 88.00
Total cost of operation		$158.00	$124.00

Heat Transfer Through Building Walls

by **M. S. Van Dusen** *and* **J. L. Finck**

Research Report 291, *pages* 493 *to* 522 *Bureau of Standards "Journal of Research," Vol.* 6, *No.* 3, *March,* 1931. *Price,* 40c *through Superintendent of Documents, Washington, D. C.*

THE report presents the results obtained in tests on 17 wall sections which included solid brick walls, furred brick walls and walls with air spaces including tile and wood frame construction. The apparatus and the methods used are described and illustrated in considerable detail. The results obtained are compared where possible with those obtained by other experimenters using similar walls but different test methods.

On pages 497 and 498 a discussion of heat flow through walls under variable conditions is given. This is a subject on which little printed information is available. The following extract is of interest in this connection: "Suppose we consider two walls, each having the same thermal resistance (measured in a steady state), but different heat capacities, such as a solid wall and a wall made up of air spaces and paper. Under the same steady conditions the heat transfer through each will be the same. Under the same varying temperature on the outside, the net heat flow integrated over a complete period will still be the same, but a different procedure must be followed in each case to maintain the inside at constant temperature. In the case of a thick solid wall, a constant heat supply will accomplish this object, assuming that the period of the fluctuation of the outside temperature is equal to 24 hours. With the air-space wall, however, more heat must be furnished to the inside during the night than during the day, since such a wall as we have assumed has very little heat capacity.

"If the object is to maintain a fairly uniform temperature indoors at all times, the solid wall has a certain obvious advantage over the wall with small heat capacity, although the consumption of fuel in each case is the same if the same temperature conditions are maintained.

"We have here considered two extreme cases for the sake of example. In actual practice, the differences between two walls having the same resistance are much less and probably not of very great importance in heating during cold weather. In summer, however, on sides exposed to the sun, walls having large heat capacity tend to keep the building cooler during the hot part of the day."

The method used in the tests is not wholly new but the apparatus has new features. The apparatus was developed with the idea of securing a practical laboratory method of measuring the heat transfer through building walls. The method consists of comparing the thermal resistance of an unknown panel with a standard, the resistance of which can be accurately measured by the hot plate method.

The following general conclusions are included and are, of course, limited to the test conditions.

1. In general, the presence of air spaces or pockets increases the insulating value of walls built of heavy clay products.

2. Furring materially increases the insulating value of ordinary types of walls.

3. The differences in insulating value between the various types of hollow tile walls tested are unimportant.

4. Judging by tests on two kinds of brick, representing approximately the two extremes in common brick manufacture, the kind of brick used in a brick wall is of little importance from the insulating standpoint alone.

5. The type of workmanship in a masonry wall may make a considerable difference in the insulating value, depending chiefly on the degree of filling of the mortar joints. Solidly filled vertical joints are not so effective from the insulation standpoint as partially filled joints.

6. The insulating value of all walls tested increases with decreasing temperature, the increase, in general, being more rapid with hollow walls than with solid walls.

"It is pointed out that investigations carried out elsewhere indicate that air infiltration through finished walls plays a minor role in heat loss from buildings. The possibilities of heat loss by partial air penetration into hollow walls are discussed at some length, and it may be inferred that there is always a possibility that an individual wall of this type may be subject to air penetration effects of appreciable magnitude.

"In conclusion, it might, perhaps, be emphasized that in an actual building, heat loss through windows, doors, and roof tends to level out the effect of differences in the walls themselves to a very considerable extent. It may, therefore, be said that although there are considerable differences in the insulating values of the various types of walls tested, the magnitude of these differences is not sufficient to make them a very important factor in the choice of building wall types, except, perhaps, in the case of relatively thin solid masonry without air spaces, where discomfort may be caused or moisture condensation produced by abnormally cold interior wall surfaces. As an illustration from another angle of the observed differences in uninsulated wall types, walls showing the lower insulating values could, by the addition of a half-inch of good insulating material, be endowed with a thermal resistance approximately as great as those showing the higher insulating values in the tests described. The difference between the poorest and the best wall from the viewpoint of thermal insulation (representing the extremes in ordinary uninsulated construction) is equivalent to approximately three-fourths inch of good insulating material."

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Methods of Economy and Care of a Building

by **T. C. Wooton**

Published by the author, 5 in. x 7½ in., cloth binding, 104 pages of text. No photos, charts, or illustrations.

THE book is written in popular style and is apparently intended for the use of janitors. It contains virtually no information of value to the technical engineer or designer.

Of the total text pages, over half, or 55 pages, are devoted to descriptive material on the general subject of heating and ventilating and the kinds of apparatus in use. The section is out of balance since nearly 30 pages are devoted to the subject of temperature control.

Descriptions of both the heating and ventilating methods in use are open to serious question in that some controversial points are stated as if they were matters of fact. It is difficult to see how janitors can obtain a true picture of either operating methods or underlying principles from the information included.

The Measurement of the Flow of Air Through Registers and Grilles

by ***L. E. Davis***

A.S.H.V.E. paper resulting from work conducted cooperatively at Armour Institute of Technology. About 2500 words, 2 graphs, 4 tables, photographs.

REPORTS a continuation of work previously reported on the determination of a suitable method for the field measurement of air flowing through registers and grilles. The anemometer seemed to be the only instrument available and the report deals with its use.

As a result of his studies the author concludes that the formula

$$\text{c.f.m.} = KVA$$

in which

V = average indicated velocity obtained by the anemometer traverse in contact with grille,
A = gross area of grille — square feet
K = an experimental coefficient,

is the most suitable one for use in measuring the flow of air with exhaust grilles. With K = 0.8 the results vary from + 11% to — 7% error. The studies included some plaster ornamental grilles as well as some of the more conventional iron grilles. The velocities of flow were of the order of 150 to 700 ft. per min. in the tests.

The studies with supply grilles were not so satisfactory and the author is continuing his studies in an attempt to devise more satisfactory methods for use with supply grilles, especially ornamental plaster ones.

As a result of a study of the effect of the human element made by having a considerable number of untrained students make observations with the anemometer, the author feels that the human element is not of great importance where a definite method of procedure in handling the anemometer is provided.

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Wind Velocity Gradients Near a Surface and Their Effect on Film Conductance

by **F. C. Houghten** *and* **Paul McDermott**

A.S.H.V.E. paper, annual meeting January, 1931, About 5000 words, 3 photos, 10 graphs, 3 line drawings.

A REPORT of data obtained during laboratory and road tests on the effects of temperature gradients set up in passing air over a surface so arranged and heated at the surface as to simulate air sweeping over the surface of a building wall. The study is incomplete and is a first attempt to measure the gradients and the film conductances using methods explained in the paper. The test apparatus is interesting and represents an application of photographic measuring to the readings of inclined liquid gages.

Data presented are analyzed to show, among other things, that the temperature gradients vary with the size of duct and with the wind velocity. Also it is made evident that wind velocity gradients for free space extend for considerable distances from the wall. Film conductances for certain surfaces, among them those studied in the test, are reported to vary between 1.4 and 2.1 for still air and to be a function of the velocity with moving air.

Your Everyday Problems

MR. HANBURGER will be glad to answer your problems relating to installation and operation of heating and ventilating systems, and wherever possible will give the reasons for his suggestions. Letters will be answered direct to the inquirer and in some cases published anonymously. If sketches are included they should be clearly drawn. Write Mr. Hanburger care of HEATING AND VENTILATING, 521 Fifth Avenue, New York.

***Conducted by* Fred W. Hanburger**

QUESTION 1. *Referring to the sketch of a steam system for a dryer room and dryer in a dry cleaning establishment, there are 200 sq. ft. of wall radiation and a coil of 300 lin. ft. of 1-in. pipe in the dryer. I estimate the coil at 100 sq. ft. of radiation, making a total load of 300 sq. ft. The main is 1¼-in. and the return 1-in. It is giving me a great deal of trouble as it is necessary to carry a pressure of over 10 lb. at the boiler and it is impossible to get the water to return to the boiler. I had to put a radiator trap at the point marked A and run the condensation into the sewer. Some tell me that the 1-in. return is too small and others say that the air drawn in by the fan creates a vacuum in the coil, but I have a quick vent installed to act as a vacuum breaker and the water sometimes spurts out of it. The fan supplies 2500 c.f.m. The return ends of the coil and wall radiators are about 8 ft. above the boiler water line. Can you tell me what to do about it?* *H. O'B.*

ANSWER. The reason that the condensation can not return is not due to the 1-in. return but to the undersized supply. While the 1¼-in. supply would be sufficiently large for 300 ft. of indirect radiation, owing to the rapid flow of air through the free area of the heater coil, the heat emission per unit of area, and the steam condensed, is very much greater than it is for direct radiation. The volume of air heated and the range through which it is heated must be the basis upon which to size the piping. The various manufacturers of such equipment have designed the coil to heat the allotted amount of air through a predetermined range, and will supply this information. Without specific information in this case we can assume the rise to be from 60° to 110° which is probably a fair assumption for this type of equipment. The system must then deliver sufficient heat to raise the temperature of 2500 c.f.m. or 150,000 cu. ft. of air per hr. through 50°. A value of 0.018 B.t.u. to heat 1 cu. ft. through 1° is sufficiently exact for our estimation.

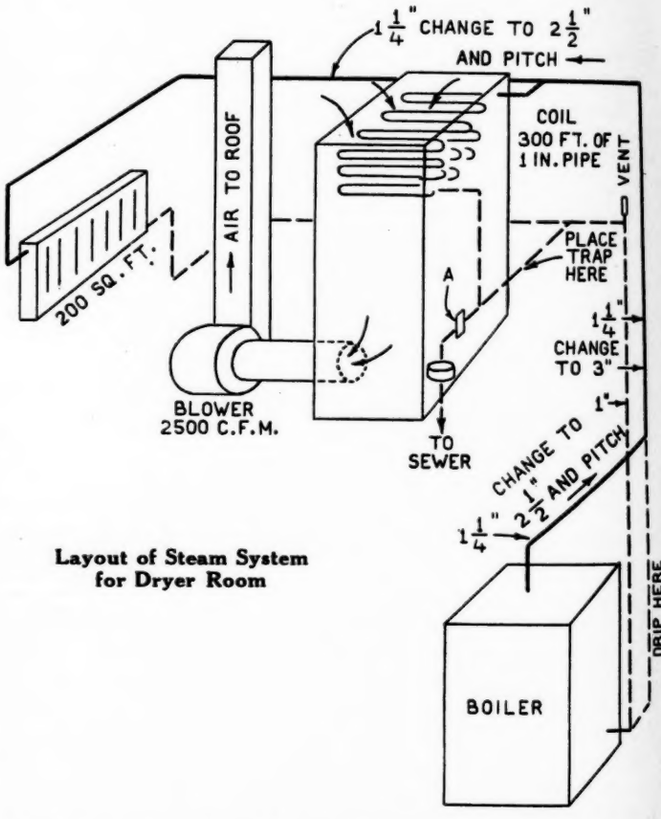
The amount of heat then needed per hour for the dryer coil will be

$$150{,}000 \text{ cu. ft.} \times 0.018 \text{ B.t.u. per cu. ft. per deg.} \times 50° = 135{,}000 \text{ B.t.u.}$$

This is equal to

$$\frac{135{,}000 \text{ B.t.u.}}{240 \text{ B.t.u. per sq. ft.}} = 540 \text{ sq. ft. of equivalent cast iron radiation.}$$

This, added to the wall radiation, gives a burden on the supply main of 740 sq. ft. It will really be greater than this during zero weather, unless there are other sources of heat in the dryer room, if the temperature of the air leaving the dryer coils is to be maintained at 110°, as the incoming air must be first heated to 60°. The actual basis for our estimation would then be 150,000 cu. ft. of air heated through a rise of 110°. This amounts to approximately 1200 sq. ft. of equivalent cast iron radiation. This indicates a 2½-in. supply main pitched and dripped as indicated on the sketch with a



Layout of Steam System for Dryer Room

3-in. riser. Radiator thermostatic traps should be used on the coil and wall radiator outlets. Their size will depend upon the type used. The return pipe where it is running as a dry return should be of a size to accommodate the traps but the 1-in. wet return can be left as it is. Taking the total length of run as less than 100 ft., the system should now function with less than 1-lb. gauge pressure at the boiler and the condensation return without any difficulty.

The reason that the condensation is held back is not due to a vacuum being formed in the coil but to the large friction loss or pressure drop between the boiler and coil. In this case for the proper amount of steam through the 1¼-in. pipe the pressure drop is about 10 lb. per sq. in. Thus, if the steam at the boiler has a pressure of, say 12 lb., that in the radiator and on the water in the return pipe will be only 2 lb. and it would need a water head of

$$10 \text{ lb.} \times 2.3 \text{ ft.} = 23.0 \text{ ft.}$$

between the boiler water line and the outlet from the radiators before the water could be returned without water logging the radiators. In this case there is but a height of 8 ft.

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QUESTION 2. I have followed your suggestion that I use higher radiators with top and bottom connections where the hot water circulation was sluggish on the lower floor, and they now heat almost as well as those on the upper floors. Can you explain the reason for this? *S. C.*

ANSWER. The force that each radiator exerts towards creating its circulation depends upon its vertical distance or height above the boiler. The upper radiators, therefore, have more power than those on the lower floors and if the piping to them is not throttled down, they will rob the latter of much of their circulation. The vertical distance above the boiler is taken to the level of the connections when bottom connections are used. When top and bottom connections are used the distance is taken to a point midway between the inlet and outlet. Consequently, using top and bottom connections on, let us say a 38-in. radiator, we are increasing its power generating height by approximately 1½ ft. If the original distance was 5 ft., then the added 1½ ft. gives an increase in power of nearly 30%, which would be sufficient to overcome any reasonable error. In general, the use of top and bottom connections for the lower radiators and bottom connections for those on the upper floors is good practice.

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QUESTION 3. I put a quantity of lime in a boiler used on a vapor system to prevent foaming and it caused the water to leave the boiler. Upon examination I found that the radiator traps no longer functioned and held the water back in the radiators so that no water showed in the boiler gauge glass. After flushing out the system to clear it of lime I still have the same trouble. The valves seem to be permanently set. Is it possible that there was enough heat emitted by the slaking lime to superheat the steam in the radiators and distort and permanently set the thermostatic bellows of the valves? *G. P.*

ANSWER. The question is a very interesting one and, in the absence of any past data or experiences of this nature, the conclusions we may arrive at can be but speculative. It is hardly probable that the amount of heat emitted by the slaking process could have caused the trouble as there would be but about 500 B.t.u. emitted from 1 lb. of pure lime and possibly but half this amount from the commercial product. Even if we inserted 2 lb. directly into the radiator itself there would be but enough heat evolved to evaporate less than 1 lb. of water, and there is always more than this amount of water hanging in a radiator. There could then hardly be any superheating of the steam.

A very probable cause of the trouble is that some of the impurities in the lime or calcium carbonate may have been deposited on a valve seat, causing the valve to lime up, prevent its closing, and so allow steam to escape into the return mains. This steam would then find its way by the back door to the remaining traps, holding them closed and logging the radiator. The fact that the radiators heated thoroughly after the system was flushed out seems to indicate that the valves were open to allow the escape of air, and the fact that they later closed as steam reached them through the returns, is an indication that most of the valves are in good order and that possibly only one or a very few are leaking. The faulty ones can sometimes be located by noting the temperature of the pipe on the return side of the trap.

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QUESTION 4. To help decide a discussion we are having in the office, will you please describe the difference between the regular two-pipe low pressure and the different vapor systems? *V. R.*

ANSWER. Hush! Hush! It is better to forget that, as you call it, the regular two-pipe system ever existed. It belongs to the days of high-wheel bicycles and hoop skirts. While all vapor systems may be of the two-pipe type yet the development and use of such excellent specialties as thermostatic traps and orifice plates have so modified the old system that the pressure in the return is always at, or very slightly above, that of the atmosphere. Hence, the name atmospheric or vapor. It is doubtful if many or any still use the old system where it was sometimes necessary to have manually controlled valves on both the inlet and outlet side of the radiators to prevent the steam from entering on the inlet side.

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QUESTION 5. I am not connected with the heating and ventilating industry but last fall I installed an extensive hot water system in my home and am anxious to know whether I shall leave the water in it during the summer. *R. M. M.*

ANSWER. It is better to leave the system standing full during the idle months to exclude oxygen which causes the oxidization or rusting of the pipes. On this basis it would appear best to leave the old water that has been used for heating during the winter because it contains less oxygen than the fresh water. Many, however, consider it better to flush out the old and refill so as to free the system of any loose matter which might harden down during the summer. When resuming heat in the fall the system should be again drained and refilled. If the system is a closed one as many of the upper vents as possible should be opened to drain the pipes as quickly as possible. It is also good practice to fill a steam system as high as it will allow to preserve it during the summer.

Correspondence

Dunham Differential Patents

EDITOR HEATING AND VENTILATING:

As Mr. Sanford's second letter* published last month apparently assumes to determine that the Dunham method patent 1,644,144 is limited to certain mechanical details, we submit the following from our patent counsel which should clarify the situation and may well serve to prevent litigation which would result from a misunderstanding of the patent situation due to the publicity given to Mr. Sanford's two statements published by you. They write:

"The Dunham patent 1,644,144 as issued covers the method of the Dunham Differential Vacuum heating system without regard to the devices used.

"We do not agree with Mr. Sanford that this patent is limited to the scope implied by him, nor that any of the matters detailed by him constitute in any degree an anticipation of your invention, or a limitation upon your patent claims.

"From our intimate knowledge of your years of research and development and of your subsequent patent applications with which we have been closely identified since 1914, we believe it to be extremely unwise for anyone to follow the suggestions of Mr. Sanford, which in our opinion would involve infringement of the Dunham patents.

"Since the Federal Courts alone can adjudicate these matters, a more detailed discussion here of Mr. Sanford's letter would be of no avail.

"Two suits for infringement of the Dunham Differential method patent are now pending and as per our advices and your instructions, other suits will be brought."

The now demonstrated success of the patented Dunham Differential Vacuum System is persuasive evidence that whatever was previously known did not teach the public how to attain the results which we have achieved, and the resulting patents cannot be lightly disregarded upon the conclusions of even so competent an engineer as Mr. Sanford, as to the scope and validity of our patent claims, especially as Mr. Sanford can have no knowledge as to the history of the Dunham inventions nor does it appear that he has even read the Dunham method patent.

Recognizing that the courts furnish the only proper forum in which to try such matters, our previous letter was only intended to call attention to the fact that certain heating procedure recommended by Mr. Sanford would come within our patent claims.

In reply Mr. Sanford entered the controversial field with the questions of law and fact which that involves and in effect attempts to interpret our patent rights.

This we cannot permit to go unchallenged, especially as we have confidently appealed to the courts for an adjudication of these matters.

C. A. DUNHAM,
President, C. A. Dunham Co.
Chicago, Ill.

Equivalent Diameters for Rectangular Ducts

EDITOR HEATING AND VENTILATING:

In the tables showing the equivalent diameters for rectangular ducts I am unable to find ducts smaller than 5 in. × 8 in. How can these data be calculated for smaller sizes?

W. A. J.

St. Louis, Mo.

Harding and Willard's "Heating and Ventilation," Vol. 1, second edition, tabulates equivalent diameters for ducts as small as 4 in. × 4 in. See page 672.

The formula is

$$d = 1.265 \sqrt[5]{\frac{(ab)^3}{a+b}}$$

where

a = one side of rectangular duct
b = other side of duct
d = equivalent diameter of round pipe for equal friction per foot of length of same capacity.

All dimensions in same units, either feet or inches.

Further Comment on Ventilation Laws

EDITOR HEATING AND VENTILATING:

I did not comment on the editorial on ventilation laws in the September issue of HEATING AND VENTILATING, because I felt that I could not endorse the sentiment expressed that the ventilation laws now in force in regard to schools are blocking progress. Neither could I see much use in trying to refute statements, too general and sweeping in their application and unsupported by actual evidence as to their validity. However, I am now going to reverse myself and speak my mind, regardless of whether I am right or wrong in my contentions.

The editorial is unfair to the laws when it says that *most* of them are obsolete and are blocking progress, and to the engineers when it intimates that they are backing up and defending such provisions as are actually obsolete. The editorial as a whole is honeycombed with sinister allusions and vague, unsupported allegations, sandwiched in between accepted tenets relative to ventilation and seasoned with innuendo implicating both named and unnamed protagonists. There is no question but that *some* ventilation laws are obsolete. Any line of human endeavor in which there is progress leaves in its wake obsolete ideas and practices. These, however, cannot be consistently charged with blocking progress. They merely stand as mute evidences of what was once considered good practice. Given sufficient time they will disappear.

The compulsory ventilation laws may be imperfect but so has everything else been that has been tested in the crucible of scientific investigation. The main idea with our ventilation laws has been to obtain ventilation where it was not wanted but where it was needed. In attempting to get this, some details were included in the requirements that are now at variance with certain practices that were unknown at the time the laws were made. These laws, or rules with the force of law, will no doubt be repealed when the validity of the changes has been effectively demonstrated. The trouble with some progressives is that they are ready to accept anything new just because the old has been attacked. Take for example the 30 cu. ft. per pupil requirement. It may be all wrong, but who has yet shown that 10, 15, 17.5 or 20 cu. ft. or any other amount is right? It would not at the present time be consistent with good scientific procedure merely to cross out 30 and substitute therefor some other number. If some other number is going in, it should have some definite basis on which it can be defended. Instead of spending a lot of effort in asserting that 30 cu. ft. is obsolete and rests on a discarded basis, efforts had better be concentrated on finding a new basis on which the amount of air required per minute for each child can be computed. This seems to be

*Differential Vacuum Heating Systems, HEATING AND VENTILATING, *March*, 1931, *page* 98.

Correspondence

one of the hard nuts to crack, and until it is cracked, we are not going to get very far in changing our ventilation requirements.

According to the editorial we don't need to crack the nut. All that is necessary is to throw the nut away, and let each school board specify how much air it wants. The editorial further goes on to say that school boards in states without ventilation laws "have reacted admirably to the propaganda on open window ventilation." This to my mind is only another way of saying that the ventilation system has been omitted.

It is by no means certain that new ventilation laws should be laid out according to lines laid down by the old, but I am unwilling to see the work of those who have framed our present requirements relegated to oblivion before we have something to put in its place. A constructive editorial along this line would strike a more responsive cord with me than one that merely harps on our professional shortcomings.

SAMUEL A. CHALLMAN
Director, Division of Buildings,
State of Minnesota.

Maintaining 70° with Vacuum Return Line

EDITOR HEATING AND VENTILATING:

Your November issue carried on page 96 an article giving a comparison of fuel consumption for two types of steam heating systems in the Montgomery Ward Buildings in Denver, Colo.

Two questions were raised editorially: (1) Can a vacuum return line system be maintained at 70° F. inside temperature without intermittent operation? (2) Is it correct to make comparisons on the degree day basis for inside temperatures other than 70° F.?

Commenting on Question 1, my experience gained over a number of years as a building superintendent has convinced me that it is possible to maintain commercial building temperatures at desired levels with vacuum return line conditions only under the following conditions: (a) When the weather is extremely cold and the system is operating at maximum capacity. (b) When hand-operated radiator valves are operated carefully. (c) When automatic temperature control equipment is added to the system. (d) When window-opening is skillfully carried out. (e) When intermittent operation is employed.

Condition (a) requires little comment. I have found, in certain buildings which are not over-radiated, that a vacuum return line system will maintain satisfactory inside temperatures during "maximum" operating periods.

Condition (b) is so rare as to be practically unobtainable commercially. There are few building occupants who will give the attention to the radiator valve necessary to provide constant temperatures. The type of temperature control system alluded to in (c) is operated by air or electricity and has proven effective in a number of special applications with which I am familiar. It adds to the system the important functions of temperature control, but also adds considerably to the over-all cost of the installation.

Window-opening referred to in (d) could theoretically be so controlled as to balance excess heat output from the radiation. In actual practice, windows are ordinarily opened only when a room becomes uncomfortably warm or stuffy and are closed only when the occupants begin to feel chilly.

Nor has intermittent operation (e) proven in my experience to be a satisfactory solution of the inside temperature problem. "On-and-off" operation brings down too many complaints on the head of the operating engineer or building superintendent.

Commenting on Question 2 from the owner's rather than the engineer's angle, if I were conducting a fuel consumption test for two types of heating systems, I would aim them both at the 70° mark inside temperature. The accuracy with which they held that mark would weigh quite as heavily in my judgment of their relative worth as would the comparison of fuel consumption.

WM. S. TREASURE
Toronto, Ont.

Relative Humidity in "Dry" Climates

EDITOR HEATING AND VENTILATING:

I have been confused by the question which has been put to me several times in the last few years. Just recently it was asked again and as I have been unable to explain the matter satisfactorily I am writing to get your opinion on the subject.

It is argued that heated rooms in homes should carry a humidity of 40% to 60% at 70°. This is a rather high humidity and the point that is questioned is why is it that if high humidities are desirable, people suffering from some pulmonary troubles are sometimes sent to dry climates like Arizona to recuperate? L. A. C.
Kansas City, Mo.

This question is very commonly asked and at first thought it certainly is confusing. The difficulty comes about from two causes.

In the first place, the high humidities of 40% to 60% advocated for use in heated rooms are commonly set at that point from considerations of comfort rather than from considerations of health. It is our opinion that the effect of humidity in the air on health has never been satisfactorily established. It is true that there have been a number of studies made and that any number of opinions have been advanced. In fact, it is usually quite possible to obtain an opinion either to the effect that high humidities are desirable or that they are undesirable if one is careful in selecting the person from whom the opinion is sought.

The second cause for the confusion lies in the difficulty of knowing just what is meant by a "dry" climate. Examination of the weather records will show in some cases at least that the so-called dry climates are not really especially dry. Regarding this point please refer to the statement made on page 6 of the Monthly Weather Review, supplement No. 6, of the Weather Bureau, dated May 7, 1917. It reads as follows:

"Climates recognized as 'dry' are not necessarily deficient in actual moisture, since even in desert regions the amount of moisture in a given unit of space may equal or even exceed that in other districts commonly considered as moist. Thus, as Yuma, Ariz., a place frequently referred to as one among the driest in the United States, there is, in July, as a rule, as much moisture in the atmosphere as at points on the Great Lakes, where the climate would ordinarily be referred to as moist. However, on account of the high temperatures at Yuma in the warm period of the year, the opportunity for water vapor to exist is greatly increased; as shown previously, the relative humidity becomes very low, the climate is considered dry, and any water exposed is quickly evaporated. On the other hand, in the lake region, the lower temperatures lessen the amount of vapor that can remain in the air and consequently it is more nearly saturated; there is less opportunity for evaporation and the climate is relatively moist."

The same publication shows that during the period from 1889 to 1913, the average monthly values of the relative humidities at 8 a.m. at Yuma were as follows:

Jan. 56, Feb. 58, Mar. 58, Apr. 54, May 56, June 56, July 63, Aug. 67, Sept. 64, Oct. 59, Nov. 56, Dec. 54.

You will note, therefore, that even at a place considered "dry" the relative humidities were still high during at least a part of the day.

News of the Month

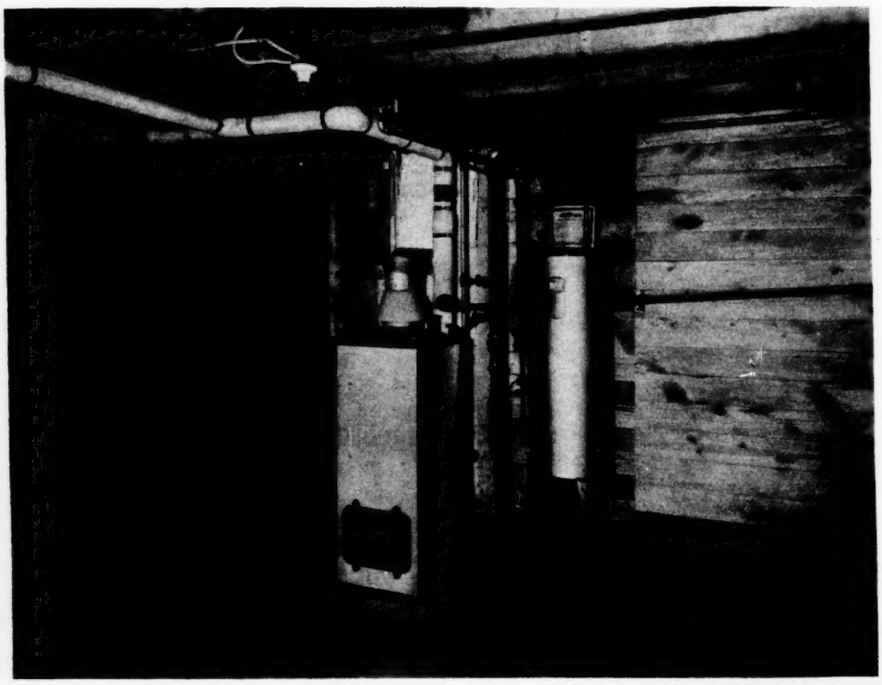
Development of 200 Homes to be Heated by Gas

According to an announcement made by A. J. Peters, general sales manager of the Consolidated Gas Company of New York, a development of 200 moderately-priced houses in Queens Village has installed automatic gas heat. This community was developed by Mezick, a prominent Long Island builder, and consists of well-built homes of 5 and 6 rooms, designed to sell for less than $9000. In addition to automatic gas heat, they will be equipped with all other modern labor-saving devices, including automatic gas water heaters.

While in the past gas heating in the New York territory had a greater popularity in more or less expensive homes, the situation was changed following several reductions in the rates for house-heating by the Consolidated Gas Company and its affiliated companies. The third reduction in August, 1930, has greatly extended the use of gas in small moderately-priced homes. This is shown by the fact that on January 1, 1930, in the territory served by the Consolidated group, the average home using gas for heating contained 586 sq. ft. of radiation, while on January 1, 1931, this figure had dropped to 532 sq. ft.

When completed, the Mezick development will be the largest in the world to be heated exclusively with manufactured gas, and will take the honor from a somewhat similar development in Baltimore which, with 110 homes, was previously regarded as the largest completely gas heated community.

Boiler Room of One of the Two Hundred Gas-Heated Homes



Expects Big Church Building Program

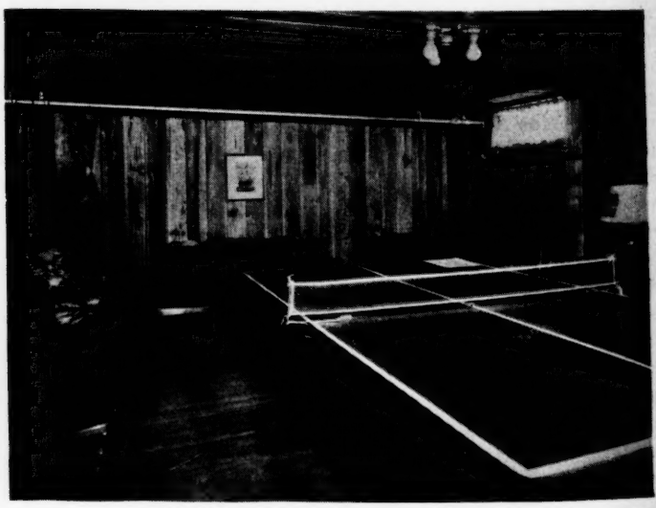
Dr. Henry E. Tralle, probably the country's foremost adviser in church building, recently made an announcement for *Church Management*, published by the Church World Press, Inc., to the effect that the country is now entering upon the greatest period of church building in its history. His reasons, based on his contacts with churches in every section of the country, are:

First, that church construction has lagged behind other types of buildings during the last fifteen years, and churches are beginning to realize that they are behind the times with their building programs.

Second, the churches have grown rich, and have the money with which to build.

Third, most of the church buildings are out of date, and built twenty to fifty years ago. In one typical town surveyed the average score for the ten best churches was a little less than 34%.

One of the Two Hundred Gas-Heated Homes In Queens Villiage



Part of Basement Used for Playroom in Gas-Heated Development

News of the Month

Fourth, the movement for better church buildings is already under way. Among the churches Doctor Tralle is serving are twenty-five that are making surveys, having plans drawn and securing estimates. This number constitutes only a very small percentage of the total that plan to build new structures or remodel old ones.

Oil Burner Dealers Organize at A.O.B.A. Convention

Oil burner dealers unanimously endorsed the plan of organization drawn up by the board of directors of the Dealer Division of the American Oil Burner Association, at the association's eighth annual convention, held at the Benjamin Franklin Hotel, Philadelphia, April 13-18.

Two points unanimously decided upon were that, based upon the results of replies to a questionnaire, the dealer organization should continue as a division of the American Oil Burner Association, and that a committee be established to formulate a definite plan of operation for the division. R. S. Bohn was appointed chairman of the committee, with Lionel L. Jacobs and Charles Bendix as members. This committee submitted a plan that the Dealer Division should have a paid executive manager with no other duties excepting those of the welfare of the dealer organization, and the division should have a separate financial set-up. The plan further provided that to collect the necessary finances, manufacturer members should charge each dealer or distributor 25 cents per burner at the time the invoice is made, and the manufacturer is to contribute a like amount.

At the merchandising session of the convention, held Wednesday, April 15, Haldeman Finnie, vice-president and general manager of the Timken-Detroit Company, spoke on "Reaching the Mass Market." According to Mr. Finnie, half a million burners a year in 1935 should be the objective of the oil burner industry. To reach a mass market large enough to be able to absorb this quantity of burners annually it is necessary that certain phases of oil burner sales be improved. The first requirement is that burner manufacturing costs be reduced, and this can be brought about only through elimination of waste and adoption of more efficient manufacturing methods. It will also be necessary to effect lower installation costs. With respect to the latter, one of the greatest handicaps, according to Mr. Finnie, is the restricted ordinances in many parts of the country. As an example, the speaker mentioned that there are eight different prices for a 275-gal. tank installation within 15 miles of New York, the prices ranging from $395 to $545.

Mr. Finnie traced the cause of this condition to the fact that no constructive effort has heretofore been made by the industry to encourage the adoption of oil burning regulations fair to the industry and satisfactory to everyone concerned. The work of the A.O.B.A. has brought about a notable improvement in this connection since it has become active in contacting municipal authorities in many territories. The speaker further stated that oil burner dealers must be criticised for their apathetic attitude in this matter of oil burner regulations.

Lionel L. Jacobs discussed "Problems We Must Analyze and Solve." He divided the problems into three divisions, the first being some problems from the buyer's standpoint; the second, some problems from the dealer's standpoint; and the third, some problems from the manufacturer's standpoint.

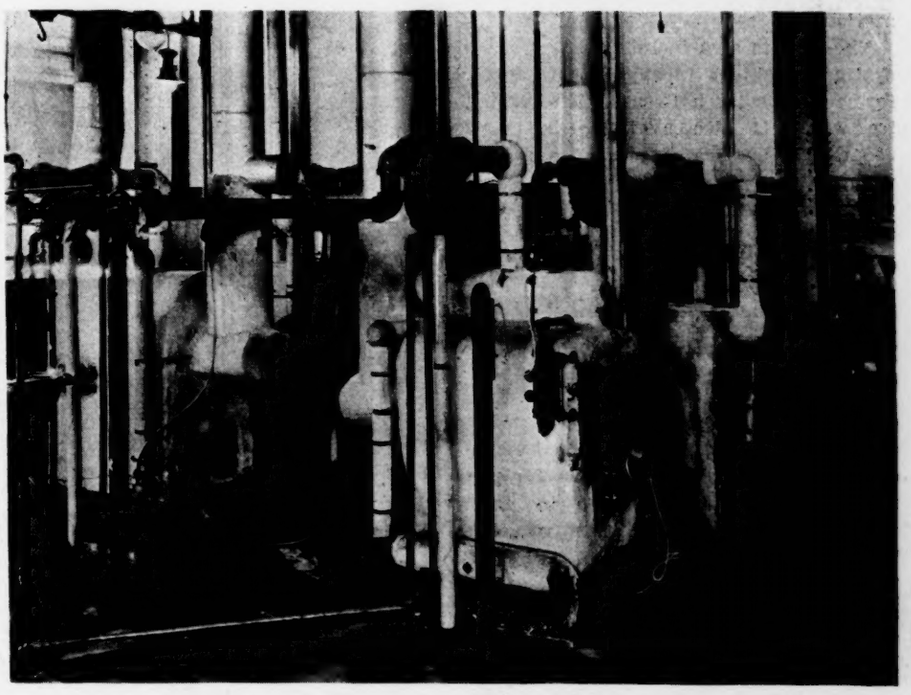
At the engineering session held Friday, April 17, P. S. Russel, research engineer of the Detroit Lubricator Company, spoke on "Controls and Accessories." J. T. McTarnahan, vice-president of the Holby Burner Corporation, who was unable to present his paper in person, prepared a paper on "Burning Heavy Oil." He stated that, in order to reduce friction losses in the line, the oil suction line between the tank and burner should be not less than 2 in. when burning heavy oil. In the discussion it was pointed out that a 1¼-in. pipe might be large enough in the case of small installations. Mr. McTarnahan mentioned the importance of a thorough survey of the job before the installation is made.

"Oil Fuels and Their Relations to the Problems of the Industry," was the subject of a paper by W. H. Butler, liquid fuel technologist of the Standard Oil Company of New Jersey. Mr. Butler recommended a reduction in the number of grades of fuel oil, and suggested that when burners are tested the fuel used should have properties in the lower range of the grade used. He urged further cooperation between the oil burner manufacturers and dealers on one hand and the oil refiners and distributors on the other.

Professor L. E. Seeley, of Mason Laboratory, Sheffield Scientific School, Yale University, presented a complete progress report on the oil burner testing program being carried out at Yale as a cooperative activity between the American Oil Burner Association and the American Society of Heating and Ventilating Engineers.

An interesting point shown on Professor Seeley's slides was that the efficiency of the burners with various boilers ranged from 63% to 83%. One burner when tested with two different boilers showed a difference of efficiency of 12%.

Walter F. Tant was reelected presi-



Boilers and Oil Burners Being Tested for A.O.B.A. at Yale University

News of the Month

dent, H. Finnie, W. J. Smith, W. C. McTarnahan, J. H. Hirsch, and Lionel L. Jacobs were elected vice-presidents of the association.

California to Have Air Conditioned Hotel

Construction of Hotel De Anza with air conditioning in every room, has been started at Calexico, Calif., by the Austin Company, engineers and builders. Will R. Conway, west coast hotel magnate, is the owner of the hotel named in honor of Captain Juan Bautista De Anza, one of the first white men ever to cross into the Imperial Valley. The project represents an investment of $380,000.

The Hotel De Anza will be the first hotel in California to be completely air conditioned. The public rooms and guest rooms alike will be supplied with conditioned air, owing to the changeable climate in the Imperial Valley. At times, the air is hot and dry, and at other times hot, with a high relative humidity, and the system is designed to operate both as a de-humidifying system and evaporating cooling system. The air circulating apparatus consists of three complete plants, one supplying the public rooms, one the guest rooms in the south portion of the hotel and the other the guest rooms in the north section.

The system also includes three refrigerating machines to supply cold water for cooling in the hot season. Circulating ice water is also available in every room. The heating system is a two pipe vacuum steam plant, with concealed radiation in the lobby and dining room.

Zink Discusses Welding at A.W.S. Meeting

John H. Zink, chairman of the subcommittee on welding, of the Heating and Piping Contractors National Association, and largely responsible for the welding handbook published by that association, addressed the annual meeting of the American Welding Society on "Welding of Heating and Industrial Piping." Mr. Zink's paper was presented at the technical session on piping held April 23. The meeting was held in the Engineering Societies Building, New York.

Standard for Heat and Thermodynamic Symbols Adopted

A new tentative standard, Symbols for Heat and Thermodynamics, has been approved by the American Standards Association. The standard is the result of extensive work by the sub-committee for heat and thermodynamics of the sectional committee on scientific and engineering symbols and abbreviations. This committee cooperated with the International Electrotechnical Commission and with the National Research Council in the preparation of the standard.

The symbols for heat transmission included in the present standard were adopted jointly by the subcommittee on symbols for heat and thermodynamics and by the committee on heat transmission of the National Research Council following extensive correspondence between the two bodies.

The new standard will be of interest to power plant designers, turbine engine designers, boiler designers, and all others working with the problems involving the transfer and transmission of heat.

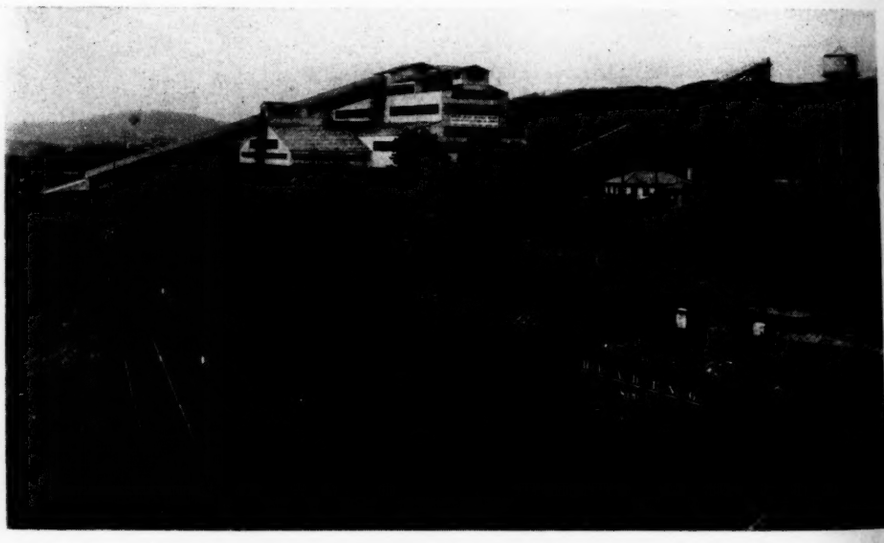
Cincinnati Certified Heat Plan May be Extended

Certified Heating as a compulsory measure was adopted by the Heating and Piping Contractors Cincinnati Association early in 1930. The plan has thus been in operation over a year. Its adoption involved the use of a surveying plan whereby the requirements of each job are determined in advance of submitting bids. The requirements are established by an engineer employed by the association and are made in accordance with the standards of the national association. After a year of experience the plan seems to be working out well. S. M. Roath is the engineer employed by the Cincinnati association and he reports that the results obtained in the way of better heating plants have more than offset the added work made necessary by the plan. It seems possible that the Cincinnati method of operating certified heating may be extended.

Building Increases in Leading Centers

The total value of building permits issued in March, as reported to Bradstreet's by officials of 202 leading cities, was $140,204,607, as compared with $95,210,648 for February, and $154,423,067, for March, 1930, an increase of 47.2% over February, and a decline of 9.2% from March a year ago. While the chief quantitative advance is that reported for New York, the percentage increase is larger in several other cities, notably Chicago, Minneapolis and Los Angeles.

Reports of contracts awarded, by the



World's Largest Anthracite Breaker

A Daily Capacity Output of More Than 16,500 Tons of Anthracite is obtained at the Locust Summit Central Breaker of the Philadelphia and Reading Coal and Iron Company, Built by Stone & Webster.

Car Loads of Coal are Fed into the Breaker at the Rate of One Every Two and a Half Minutes. The Conveyor Belts Carry this Coal to the Machinery which Sizes and Cleans it, and Removes Impurities at the Rate of 1200 Tons Per Hour. The Inclined Structure, Beginning at the Left and Leading to the Top of the Breaker Contains the Conveyor Belts. The Pipe Lines at the Right Enclose Other Conveyor Belts which Carry Off Incombustible Material which is Removed in the Breaker.

News of the Month

F. W. Dodge Corporation, indicate a total of $370,406,300 for March in the 37 states east of the Rockies, in comparison with $235,405,100 in February. This was divided into $101,337,600 for residential buildings, $117,346,900 for non-residential and $151,721,800 for public works and utilities.

With the lower construction costs now obtainable, it is believed that floor space represents new construction volume more accurately than valuation figures. On a floor space basis residential contracts exceeded the corresponding in 1930 by more than 2%.

British Experimental House May be Modified

At the annual meeting of the Institution of Heating and Ventilating Engineers, held in London, February 11, the question of research work was taken up and appeals were made for funds so that the institution could demand from the Government Research Department that attention should be given to heating problems. It was suggested that in addition to carrying out research work on heating apparatus, some private research work would be found in order to keep the plant and personnel fully occupied.

The experimental house is to be provided with double walls, floors and ceilings, fitted with warming panels, etc., in order that actual weather conditions can be duplicated and thus make it possible for reliable tests to be recorded.

Sam Fox was elected president of the institution for the coming year.

Bill for Changing New York School Ventilation Law Vetoed

Governor Franklin D. Roosevelt of New York vetoed, during April, Assembly Bill No. 552, commonly known as the Mastick Bill, which was passed by both the House and the Senate of the State of New York during the month. The bill provided for the amendment of the education law in relation to plans and specifications for construction of school buildings by eliminating those paragraphs which provide for 30 cu. ft. of pure air per min., 35% humidity, etc.

The bill would have called for 15 sq. ft. of floor space and 200 cu. ft. of air space for each pupil as does the present law, but the ventilation requirements were not included.

Gas House-Heating Increases

According to the monthly summary of statistics from manufactured gas companies, issued by the American Gas Association, the number of customers for gas house-heating in January showed an increase of 26.6% in the New England states over the same month last year. For the east north central states the increase was 9.1%. The largest single increase in house-heating was in Pennsylvania where the number of house-heating customers increased from 2436 to 3494, a gain of 43.4%.

Bituminous Coal Used for Heating is 20% of Total Consumption

According to a statistical survey made by the Coal Division of the United States Bureau of Mines, the consumption of bituminous coal for domestic purposes, heating large buildings other than factories, central heating plants, etc., amounted in 1929 to 102,000,000 tons, or 20.4% of the total 500,129,000 tons consumed.

Olchoff to Address A.S.R.E. on Air Conditioning

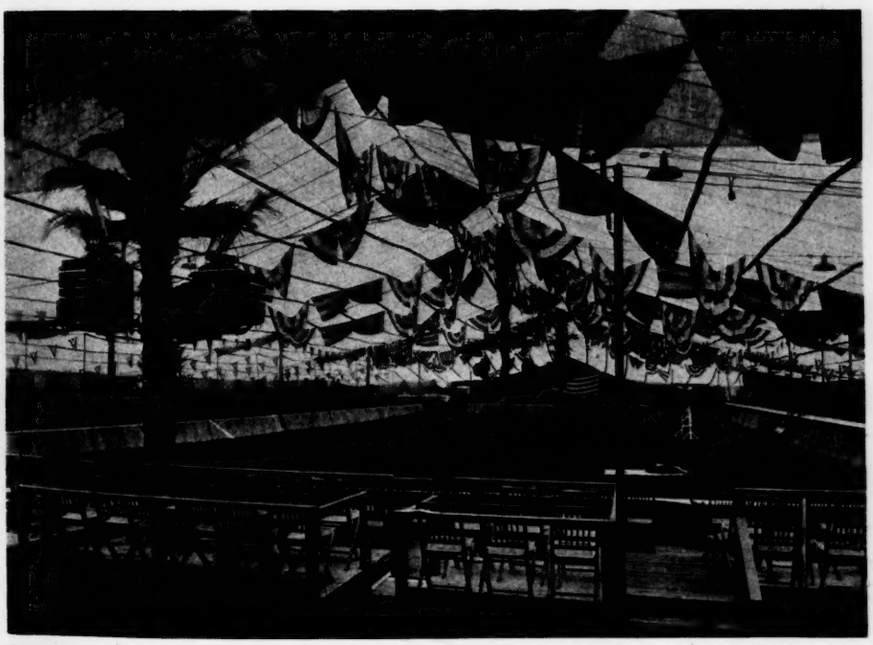
Maurice Olchoff, Natkin Engineering Co., Kansas City, will present a paper on "Refrigeration in Air Conditioning" at the eighteenth spring meeting of the American Society of Refrigerating Engineers, to be held in Kansas City, Mo., May 6-8. Other papers include "Design of Drinking Water Systems," by R. H. Tait, consulting engineer of St. Louis; "Bakery Refrigeration in Practice," by A. W. Archer of Archer & Lloyd, Kansas City; "Control of Brines and Refrigerants," by T. W. Carraway, Schwitzer-Cummins Co., Indianapolis, and "Chemistry of Water Hardness by Dana Burks," University of Illinois.

A.G.A. Expects Trade Associations to Make New Move

Growing opposition on the part of trade associations to the present attitude of the Federal Trade Commission is indicated in a letter which has just been sent to members of the manufacturers' section of the American Gas Association.

According to Philip O. Deitsch, manager of group activities of this section, a meeting of representatives of important trade associations in the near future is at present under contemplation in order to coordinate their activities in opposition to the commission's policy of reviewing existing trade practice rules.

It is known that a meeting of various trade associations who have trade practice rules which have been submitted to the Federa' Trade Commission will be held in Atlantic City shortly



Unit Heaters Maintain Comfortable Temperatures in Horse Show

Ten Overhead Unit Heaters were Used in the Tent Housing the Los Angeles-Beverly Hills Midwinter Horse Show. The Tent was 180 Ft. x 300 Ft. x 30 Ft. and Accommodated 5000 People

News of the Month

in connection with the meeting of the Chamber of Commerce of the United States and it is possible that the plans mentioned in Mr. Deitsch's letter may be worked out at that time.

Carrier Addresses New York Heating Engineers

W. H. Carrier, national president of the A.S.H.V.E., addressed the New York chapter of the society on "Servicing the Human Power Plant" at the annual meeting of the chapter held April 20. Mr. Carrier dicussed body heat losses and presented curves showing the amount of heat lost from the body by different means, comfort charts, and other material based on work done by the research laboratory.

Officers elected for 1931 are: Russell Donnelly, president; Louis T. M. Ralston, vice-president; F. E. W. Beebe, treasurer; W. A. Swain, secretary. New members elected to the board of governors were Raymond Newcomb, Albert L. Baum and Alfred J. Offner.

Purdue to Hold Short Gas Heating Course

Heating homes with gas will be the theme for a short course for gas engineers to be held at Purdue University, Lafayette, Ind., on May 19-20, according to the announcement made by Prof. R. B. Leckie, of the Purdue school of chemical engineering. Plans for the course were formulated at a recent meeting of representatives of utility companies, at which Professor Leckie was selected to direct the course. He will be assisted in arranging for the course by several utility men, including Glen Myers, of South Bend; B. M. Denlow, Indianapolis; R. Mesnard, Hammond, and R. Bowers, of Fort Wayne.

Installation, adjustment, and repair of gas heating equipment for homes will be the principal topics for the course. The conference is expected to attract men from gas companies in all parts of the state.

324 Manufactured Gas Companies Have House-Heating Rates

According to a list published by the statistical department of the American Gas Association, there are 324 manufactured gas companies which have special rates for house-heating. This figure includes those companies whose regular rates are low enough to encourage heating.

So far as the number of companies is concerned, with no reference to their size, Massachusetts leads, having 48 companies with special rates. Pennsylvania has 28 and New York, 27.

The list does not include natural gas companies, few of whom have special house-heating rates. The general service rate is generally adequate to secure heating customers.

N.F.P.A. Revises Oil Burner Booklet

The revisions in the Regulations for the Installation of Oil Burning Equipment, edition of 1928, prepared by the National Fire Protection Association committee on flammable liquids and adopted by the association at its 1930 annual meeting, with the supplementary revision approved by the association's board of directors at its mid-winter meeting, have been printed in a two-page leaflet. Copies can be obtained from the offices of the association, 60 Batterymarch St., Boston, Mass.

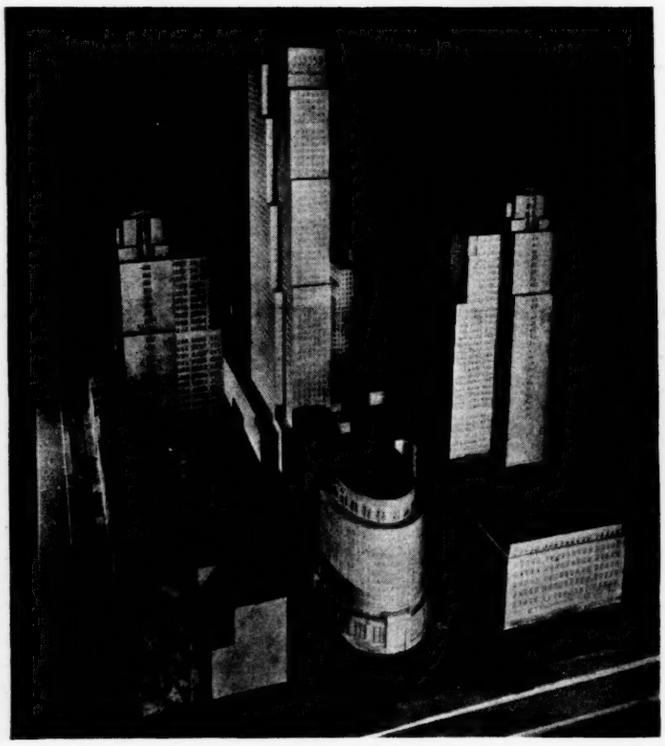
Prize Awards for Quantity Surveyors

The American Institute of Quantity Surveyors is offering prizes for the best quantity surveys on each trade in the building industry. Competition closes May 15. Contestants are requested to forward their surveys to the Secretary, F. E. Dischner, 910 Empire Bldg., Detroit.

Difficulties Encountered in Building Windowless Factory

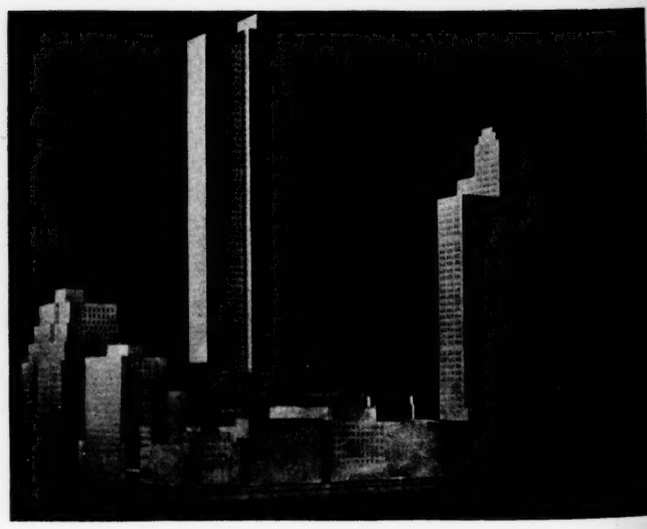
Industry's first windowless factory, now being built for the Simonds Steel Industries at Fitchburg, Mass., has its unusual construction problems as well as its unique operating features.

The Austin Company of Cleveland, engineers and builders who designed and are erecting this $2,500,000 "controlled-conditions" plant, have been



New York's $250,000,000 Future Radio City

The lower fifteen stories of the central office building will be occupied by a broadcasting company and will be air conditioned. Tall picture shows the model from the corner of 48th Street and Fifth Avenue, while the low photograph shows the development at 48th Street and Sixth Avenue.



News of the Month

forced to devise temporary lighting and heating systems to function before the permanent systems are ready.

When work was completed on the walls and roof, the interior was left in total darkness, so an emergency lighting system was installed until the permanent fixtures were delivered. The permanent fixtures of revolutionary design will be ready within a few weeks.

When the plant was completely encased, the severe New England winter left a deep deposit of ice and snow on the floor before the roof had been covered. With the plant's insulated walls, the factory assumed the characteristics of an ice house. Salamanders could not be used because there was no way to carry off fumes and gases generated.

The construction engineers fired up the boilers and attached fan blowers over steam pipe coils for circulating warm air to thaw out the ground, and make workmen comfortable. Doors and ventilators had to be opened frequently to allow moisture and air to leave the building. The permanent heating system involves extensive overhead blowers, with the air leaving the plant through underground ducts.—*Refrigerating Engineering*

Government Booklet to Deal With Home Insulation

Appointment of a sub-committee to prepare a booklet which will acquaint builders, as well as present and prospective home owners, with the facts in regard to insulating a house, is announced by Secretary of Commerce Robert P. Lamont, chairman of the national committee on wood utilization. The preparation of this publication is one of the special projects of the committee.

The national committee on wood utilization has for its object the furthering of efficient wood-using practices. The preparation of the insulation booklet is a logical step in this direction, because many of the insulating materials now on the market are made from wood. The publication will be prepared from an impartial viewpoint, treating practically all types of insulating materials.

Members of the sub-committee sponsoring this project and the organizations they represent are as follows: LeRoy E. Kern, American Institute of Architects, chairman; M. C. Betts, American Society of Agricultural Engineers; William F. Chew, National Association of Builders Exchanges; W. H. Ham, Better Homes in America; E. J. Harding, Associated General Contractors of America, Inc.; C. H. Osborne, Building Officials' Conference; William S. Quinter, U. S. League of Building and Loan Associations; Leonard P. Reaume, National Association of Real Estate Boards; F. B. Rowley, American Society of Heating and Ventilating Engineers; W. A. Slater, consulting engineer; James S. Taylor, Bureau of Standards; S. Percy Thompson, National Retail Lumber Dealers Association.

Delegates from 50 Cities Will Attend H. & P. C. N. A. Convention

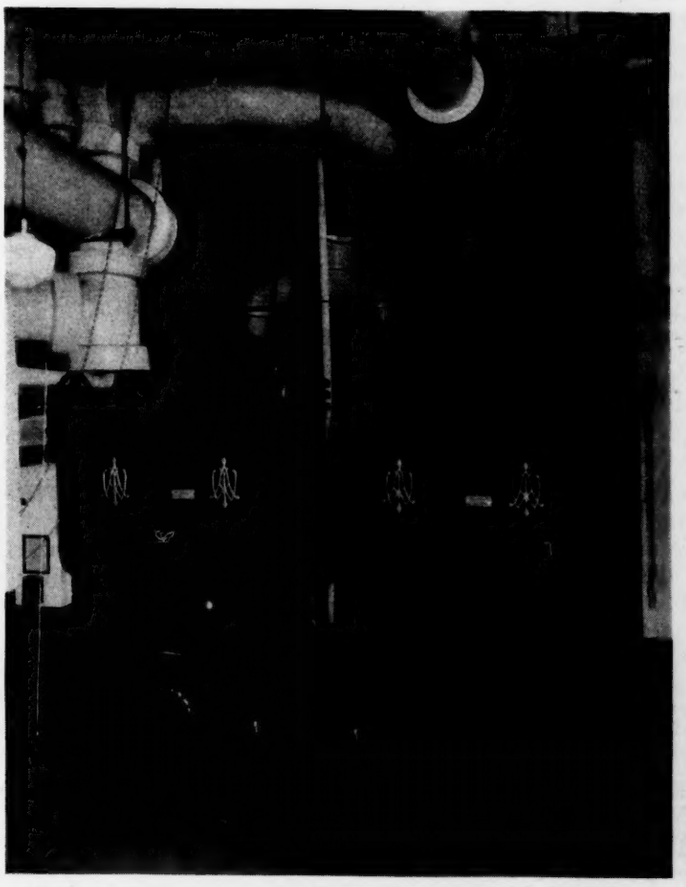
Approximately 50 cities will be represented by a delegation to the forty-second annual convention of the Heating and Piping Contractors National Association to be held here May 6-9, inclusive, it was announced today by M. J. Chagnard, chairman of the convention executive committee. Joseph C. Fitts, New York, national secretary, has given his endorsement to convention arrangements and states that the program dealing with various phases of technical and trade practices appears to be one of the most interesting ever presented at any of the association gatherings thus far held.

Headquarters for the convention will be at the Kentucky Hotel. Those assisting Mr. Chagnard on the executive committee are C. J. Redmon, O. C. Krause, W. C. Gibson and F. A. Clegg.

Unusual Weather Conditions During March

The weather report for March, shows a continuance of temperature above normal at New York and Boston, and a noticeable change to cooler at Pittsburgh and St. Louis. At Chicago the mean temperature changed from day to day only 2.5° (unprecedented) and averaged only 0.5° below the monthly normal. The average daily range in temperature in the Windy City was only 7.8°, which is not much above half the normal and is the least of record for the month of March.

At Boston, New York and Chicago there occurred an excess in precipitation for the third time in fifteen months. The significance of this remark is understood when it is stated that the deficiency in precipitation for the period indicated was 14 in. at Chicago; 10 in. at New



Two of the Seven Oil-Fired Heating Units in London Terrace, in New York City, the World's Largest Apartment House. Four Burners Fire Four 2000 Hp. Boilers. There are 1665 Apartments Under One Roof.

News of the Month

York and 8 in. at Boston. Cloudy weather predominated at these cities, including Pittsburgh, to an extent unprecedented in March records.

But Chicago was otherwise storm beaten. A trace or more of precipitation occurred on twenty days, being snowfall during the first 19 days of the month and rainfall thereafter. The total snowfall of 19.8 in. was nearly three times the normal for March.

N.W.A.H.A. and Furnace Institute Merge

At the annual convention of the National Warm Air Heating Association, held in Columbus, Ohio, April 22-23, the merger of the association with the Warm Air Furnace Institute was formally approved.

Engineering papers were presented by Professors Willard and Kratz and S. Konzo, V. S. Day, and A. M. Daniels.

New officers elected were: President, I. L. Jones, International Heater Company; vice-presidents, W. L. McGrath, Williamson Heater Company, and H. T. Richardson, Richardson & Boynton Company; managing director and treasurer, Allen W. Williams.

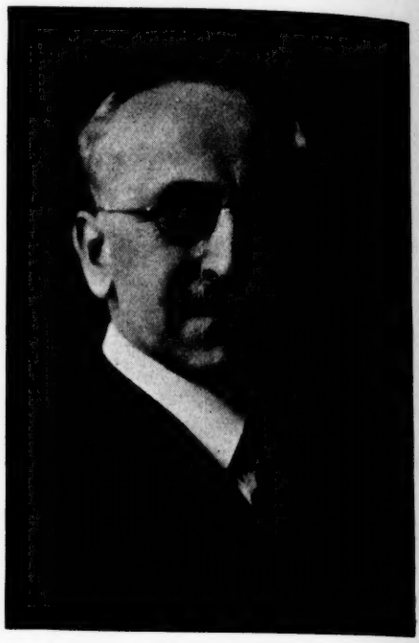
Directors elected were: H. P. Mueller, L. J. Mueller Furnace Company; Ralph Blanchard, Hart & Cooley Manufacturing Company; F. E. Mehrings, Meyer Furnace Company; A. W. Wrieden, Holland Furnace Company; Clarence A. Olsen, Fox Furnace Company.

Professor Arthur J. Wood

Professor Arthur J. Wood, Head of the Mechanical Engineering Department, Pennsylvania State College, died April 18 from injuries received when he was struck by a motorcycle earlier in the day.

Arthur Julius Wood was born September 3, 1874 in Newark, N. J. His father was a professor of thermodynamics at the University of Michigan, and later of mechanical engineering at Stevens Tech.

He was graduated from Stevens Institute with the degree of Mechanical Engineer in 1896, and for the four years immediately thereafter was associate editor of the Railroad Gazette. From 1900 to 1902 he was an instructor in Worcester Polytechnic Institute, and went from there to Delaware College as professor. He went to Penn State in 1904 with his wife Helen N. Kerr, whom he had married that same year. From that time until 1908 he was assistant professor of experimental engineering, being promoted to associate professor and holding that rank to 1910, when he was made associate professor of railway mechanical engineering. In 1918 he was made Professor of Railway Mechanical



Arthur J. Wood

Engineering and in 1922 was made Head of the Department of Mechanical Engineering with a full professorship. For three years, from 1919 to 1922, he was in charge of the Thermal Plant of the Engineering Experiment Station.

He was president of the American Society of Refrigerating Engineers during 1929; had served the American Society of Mechanical Engineers on its committee on heat transfer, and also as chairman of the Central Pennsylvania section, in 1922. He was a member of the American Railway Association, Society for the Promotion of Engineering Education, a fellow of the American Association for the Advancement of Science, honorary member of Sigma Tau fraternity, and a member of the honorary engineering fraternity, Pi Tau Sigma.

Coming Events

May 6-9, 1931. Annual Convention of Heating and Piping Contractors National Association at Louisville, Ky. Headquarters at the Kentucky Hotel.

May 11-13, 1931. Convention of National Pipe & Supplies Association. Headquarters, Hotel Hollenden, Cleveland, Ohio.

May 11-14, 1931. Natural Gas Department Convention of the American Gas Association, to be held at Memphis, Tenn. Headquarters, Hotel Peabody.

May 21-22, 1931. Second Midwest Bituminous Coal Conference, at the University of Illinois, Urbana, Ill.

May 25-27, 1931. Sixth Annual Convention of the American Institute of Quantity Surveyors. Headquarters at the Netherland Plaza Hotel, Cincinnati, Ohio.

June 2-5, 1931. Annual Convention of the National District Heating Association in Boston. Headquarters at the Hotel Statler.

June 8-11, 1931. Annual Convention and Informashow of the National Association of Purchasing Agents in Toronto, Canada. Headquarters at the Royal York Hotel.

June 22-25, 1931. Forty-Ninth Annual Convention Exposition of the National Association of Master Plumbers, to be held in Milwaukee, Wis. Headquarters at the Milwaukee Auditorium.

June 23-26, 1931. Summer Meeting, American Society of Heating and Ventilating Engineers, at Swampscott, Mass.

July 13-17, 1931. National Association of Building Owners and Managers. Headquarters at the Olympic Hotel, Seattle, Wash.

September 7-11, 1931. Annual Convention and Mechanical Exposition of the National Association of Power Engineers. Headquarters at the Convention Hall, Kansas City, Mo. Secretary, Fred W. Raven, 417 S. Dearborn St., Chicago.

October 12-13, 1931. Thirteenth Annual Convention and Exhibition of the American Gas Association, Municipal Auditorium, Atlantic City, N. J.

November 30-December 5, 1931. First National Exposition of Mechanical Handling at the Grand Central Palace, New York.

January 25-28, 1932. Joint Annual Meeting of the American Society of Heating and Ventilating Engineers, and the American Society of Refrigerating Engineers, at Cleveland, Ohio.

January 25-28, 1932. Second International Heating and Ventilating Exposition, at Cleveland, Ohio.

News of Consulting Engineers

M. G. Harbula, consulting air conditioning engineer, announces the removal of his Chicago offices to 693 Park Blvd., Glen Ellyn, Ill.

Arthur E. Christen, consulting engineer, announces the opening of offices at 454 Nicholas Building, Toledo, Ohio, for mechanical and electrical engineering work.

Robert L. Baker, well known to the heating and ventilating industry in Boston, Mass., has joined the staff of Fay Spofford & Thorndike, Boston architects, as a heating engineer.

New Apparatus and Appliances

Compact Air Filter

A new type of dry air filter has been announced by the Independent Air Filter Co., 29 South Clinton St., Chicago, Ill. It consists of a series of superimposed hinged wings, or panels, into which a continuous sheet of fabric or fibrous filter medium is folded. The filter is known as the Compact and, as its name implies, encompasses a large amount of filter surface in a small frontal area. Each installation is made up of three elements—filter unit, shelf, and the main frame. The wings of each spacer are coupled to those of the spacer adjacent, the effect being that of a continuous hinge.

The filter medium commonly used is called Filterdown. It is fluffy and fibrous on the dirty-air side and closely woven and glazed for tensile strength on the clean-air side. Made in a variety of weights and substances, it comes in a convenient size 20 in. wide. Prices range from ½c per sq. ft. to 1¼c per sq. ft.

Compact Dry Air Filter

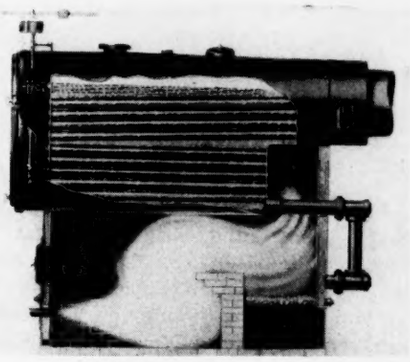
The rating applied to the unit is 600 c.f.m. With this rating the velocity through the filter material is 22.5 f.p.m., and the initial resistance 0.15 in. water gauge.

The manufacturer recommends that velocities used in design should not exceed 25 ft. per min. through the filter.

Pacific Triplex Steel Boiler

Pacific Steel Boiler Corp., Detroit, Mich., announces its Triplex steel heating boiler, a fire-tube boiler for combination service for heating, hot water and garbage incineration. Submerged copper coil units, built in the unit but readily removed for cleaning, furnish domestic hot water without the use of a storage tank. Incinerator grates are provided in the rear of the firebox.

Ratings are given based on the code of the Steel Heating Boiler Institute, the rating depending on the heating surface and combustion volume. The boilers are available in 37 sizes, with ratings ranging from 1740 sq. ft. to 29,780 sq. ft., net, of steam radiation. Data included in the manufacturer's folder is unusually complete in giving heating surface, ratings for both radiation and water heating capacity, asbestos required to cover, grate area, dimensions, etc.



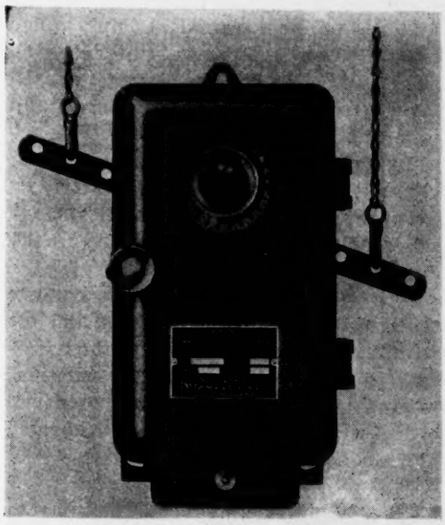
Pacific Boiler for Heating, Hot Water and Incineration

Stat-Amatic Master Control Unit

A master control unit which will control any number of dial thermostats and, when equipped with a program dial, provides a flexible and automatic control of night and day temperatures over week-ends and holidays, is announced by the Stat-Amatic Instrument & Appliance Co., Hartford, Conn.

The program dial is for the purpose of lowering the temperature over the week-end or holidays, and automatically bring it back to normal on Monday or the day following the holiday.

The program dial consists of two dials mounted on a common drive shaft. The lower and larger of the two dials is divided into twenty-four hours, and revolves once a day, and the operating pins may be moved at will. In a factory, these pins would be set at about 5:30 at night, and 5:30 or 6:00 o'clock in the morning, so as to shift the lever from, say, 70° during the day to 60° during the night, and back to 70° in the morning. The upper dial is divided into the days of the week and revolves once a week. The pins on the upper dial may also be moved at will to block off any desired period, such as from 12:30 at Saturday noon to 5:30 or 6:00 o'clock Monday morning. When thus set, the night temperature level is held over the week-end, resulting in considerable fuel saving during the period the building is unoccupied.



Stat-Amatic Master Control

Cope-Swift Oil Burner

Announcement of a new oil burner has been made by Cope-Swift Corp., 247 McDougall Ave., Detroit. A feature is the atomizing of the oil by a triplex cup mounted on the fan assembly, the oil being fed through the hollow shaft.

The oil comes through the shaft against a cone heated by exposure to the flame. Cracking is started by the heat and the oil passes backward through a nozzle with large holes. Centrifugal force then spreads it in a thin layer around the inner walls of the first cup, from which it is thrown to the second. Here a still thinner layer is struck by hot gases which are drawn through the third cup. As it is thrown in the form of a mist or fog from the edge of the cup, it is picked up and projected into the flame by the air current driven through the outer housing by the fan.

New Apparatus and Appliances

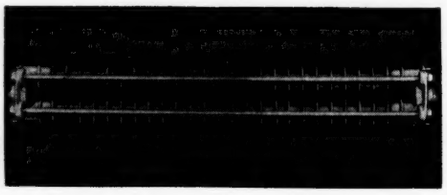
Capitol Cast Iron Concealed Radiator

United States Radiator Corp., Detroit, has announced a line of Capitol concealed radiators, made of cast iron. The radiator is compact enough to be installed in spaces as shallow as that between 2 in. × 4 in. studs. The ribs on the body are integral parts of the radiator, with no mechanical joints. The manufacturer claims that there are no small tubes to be clogged due to capillary attraction, the steam spaces and nipples being of ample size.

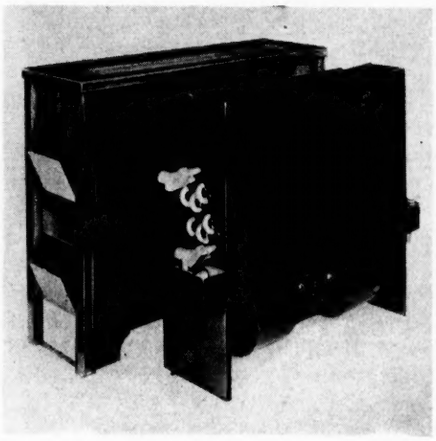
Test curves show that the operating characteristics are ideal for water systems, since the heat emission for various stack heights decreases directly as the drop in water temperatures.

It is stated in the company's catalog that the increasing use of gas and oil with intermittent firing makes the use of cast iron advisable, since this material retains the heat long enough to carry over between operations of the burner.

Three lengths of intermediate sections and three widths of headers give a wide range of assemblies. Selection of the proper unit assembly depends on the enclosure outlet, available stack height, and available length and depth.



Two Parallel Rows of Intermediate Sections are Assembled Between Two Headers to Produce a No. 2 Unit Assembly which has a Depth of 3¼ In.



Carrier-York Atmospheric Cabinet

Carrier-York Announces Comfort Unit

A unit known as the Carrier atmospheric cabinet and designed so that it may be used to heat, humidify and ventilate in winter and to cool, dehumidify and ventilate in summer, has been announced by Carrier-York Corp., Philadelphia.

An attractive cabinet encloses and conceals the entire interior assembly, including all the fittings and connections. Small doors on each end allow for inspection and for setting of controls. The cabinet has a standard art metal, hand grained walnut finish, but other finishes are available.

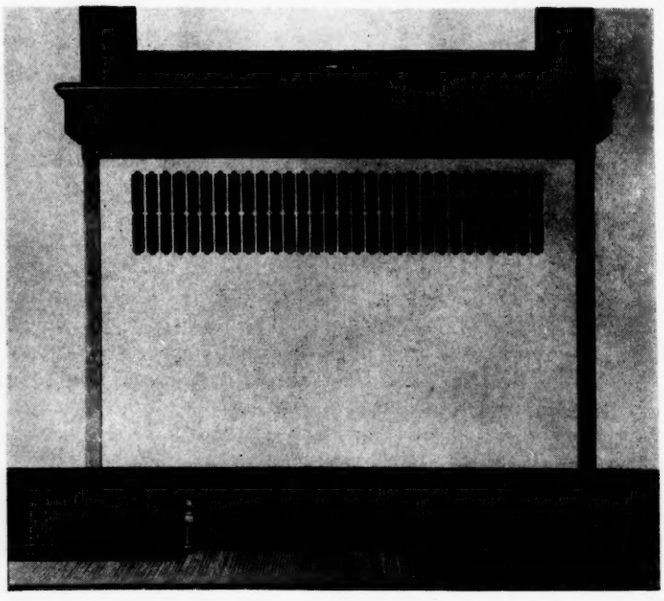
The comfort-producing portion is a complete compact casing, to which all necessary connections may be made for both heating and cooling mediums, drains and power. The air, entering at the base, may either be recirculated from the room or outside air may be introduced through an intake which contains a filter. The proportion of recirculated air to outside air is controlled by a damper. Two housed aluminum fans, especially designed and mounted for quiet operation, keep the air in constant circulation.

According to the manufacturers, the cabinet makes possible more comfortable working conditions the year round in a wide range of applications, such as offices, shops, display rooms, tea rooms and retail stores. The unit principle, requiring no duct work, makes it equally adaptable for new construction and for modernization of existing buildings.

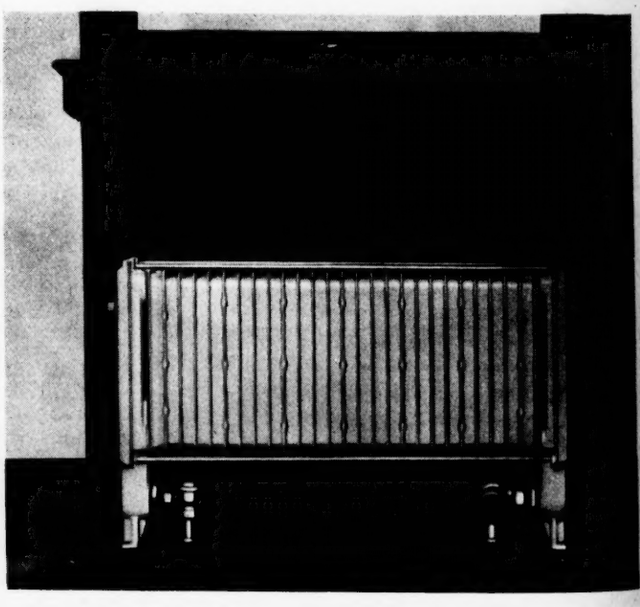
Propellair Fans

Propellair, Inc., Columbus, Ohio, has developed a new extension shaft fan of the airplane propeller type, for any application where medium pressure is built up and where motor must be kept out of air flow.

In designing the extension shaft fans Propellair engineers have paid particular attention to the length of the extension as this contributes greatly to the efficiency of the duct in which it is installed. Each extension is designed to fit into an elbow in a duct line so that the elbow proper is 1½ diameters of the duct proper. In each size this item has been kept in mind because experience has shown that with an elbow of R-1½D good results may be obtained. There is little or no advantage in mak-



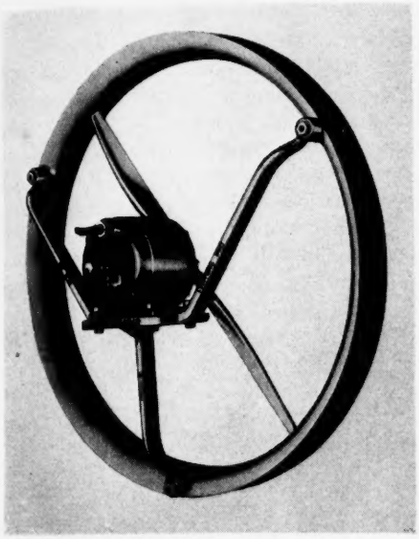
U. S. Radiator Style "M" Cast Iron Radiator



Style "M" U. S. Radiator with Metal Panel Front Removed

New Apparatus and Appliances

ing an elbow or radius greater than two diameters. If, however, a smaller radius than 1½D be used, the efficiency of the fan and duct is decreased considerably.



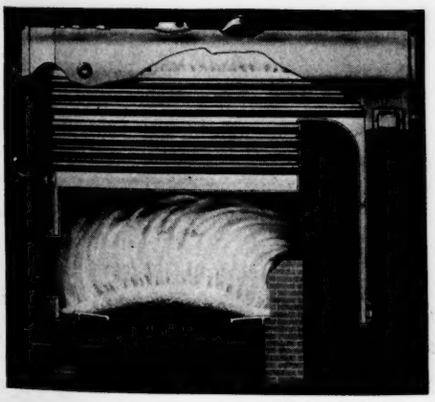
Blade of Propellair Fan Showing Curved Entrance Housing

With an extension shaft fan, with proper length extension, the installation is simplified, as well as the cost reduced. It is also claimed that the curved entrance housing or ring of Propellair fans makes possible an increased efficiency at low power cost.

Steel Boiler Designed for Stoker Firing

A high fire-box boiler has been announced by the Heggie-Simplex Boiler Co., Joliet, Ill., to meet the specifications of various types of stokers. The boiler assures adequate furnace volume without the necessity of an expensive built-up refractory setting, or countersinking of the retort of the stoker. The extra furnace volume is obtained by lengthening the water legs of the boiler itself.

Boilers are made in a range of sizes for buildings having 1600 sq. ft. of steam radiation or more.



Heggie-Simplex High Fire-box Boiler

Arcola Gas Boilers for Hot Water Heating

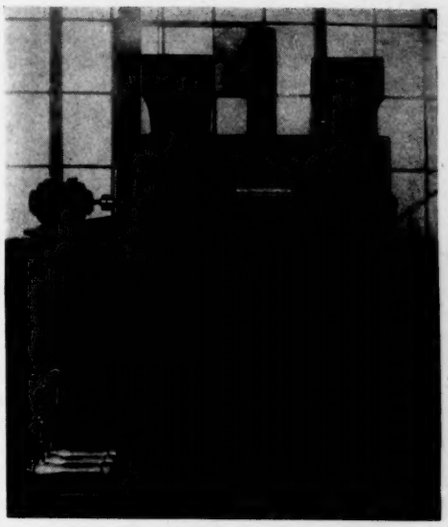
A line of small Arcola gas boilers, designed for small hot water heating systems and hot water supply systems, has been announced by the American Radiator Co., Gas Utilization Dept., 40 West 40th St., New York. The boilers can be furnished either with or without insulated jackets.

The boilers are available in 8 sizes, with capacities ranging from 210 to 840 sq. ft. of water radiation, A.G.A. rating. The company states that from 135 to 540 sq. ft. of direct cast iron radiation can be supplied. Water heating capacities range from 38 to 151 gal. of water per hr. at 100° temperature rise or equivalent.

Ideal Arcola Gas Boiler

Nichols Gas-Fired Air Heaters

The Nichols Products Corp., 12953 Greeley Ave., Detroit, Mich., announces the Nichols gas-fired air heaters of the unit type for floor mounting. The heater is a self-contained device requiring connections for gas and electricity only. It is thermostatically controlled to maintain constant room temperature regardless of outside weather conditions.



Nichols Gas-Fired Air Heater

The unit consists essentially of five principal parts: (1) a combustion chamber, insulated and equipped with low pressure burners; (2) a heating element of a large number of interlocked tubes of special shape; (3) an angle iron frame properly welded and braced to which is fastened the insulated sheet metal casing; (4) specially designed fans and air distributing outlets; (5) thermostat in cold air intake and actuating a motor operated gas valve in the main line and complete safety protection against failure of gas.

New Line of Century Motors

Century Electric Co., St. Louis, Mo., announces a new line of fractional horsepower motors having mounting dimensions interchangeable, in repulsion start induction single phase, split phase single phase, squirrel cage induction three phase, and DC types.

Bearing brackets of this design offer unusual protection against falling objects, dirt, or dripping water. These motors have rolled steel frames, welded steel feet, slotted for belt adjustment, and bearings machined from phosphor bronze castings. They are equipped with the Century wool yarn system of lubrication.

A-Jacks Steam Damper Regulator

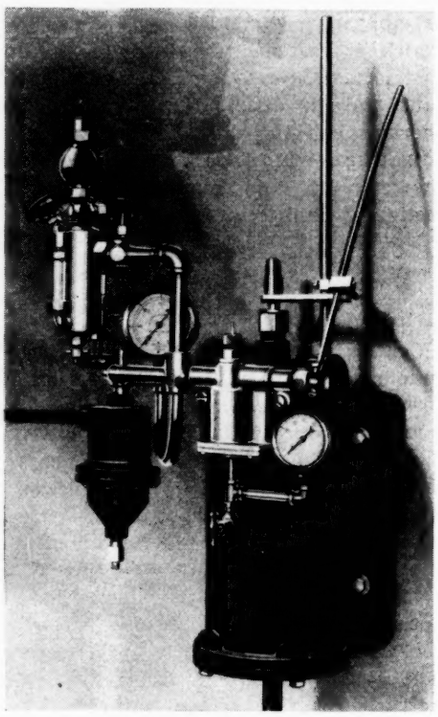
The A-Jacks steam damper regulator has been announced by the National Regulator Co., 2301 Knox Ave., Chicago, Ill. The regulators are built in a standard model for boilers carrying from 15 to 200 lb. pressure. Special regulators are built for pressure from 200 to 300 lb. On hand-fired boilers with natural draft, these regulators provide automatic control with gradual movement of the damper to compensate for variations in

New Apparatus and Appliances

steam pressure. On stoker-fired boilers with natural draft they provide automatic control with gradual action of dampers and stoker speed.

On stoker-fired or pulverized fuel burning boilers with forced draft, the regulators provide automatic control with gradual action of dampers and synchronized control of stoker and blower speeds, while on oil-fired boilers they offer a control of burner valves and motors.

When the boilers are operating at their normal pressure, the valves are opened to throw a new line into service, the regulator increases the opening of the damper, increases the stoker speed and the blower speed in order to bring the boiler pressure back to normal in the shortest possible time. The reverse takes place when a line is cut out of service.

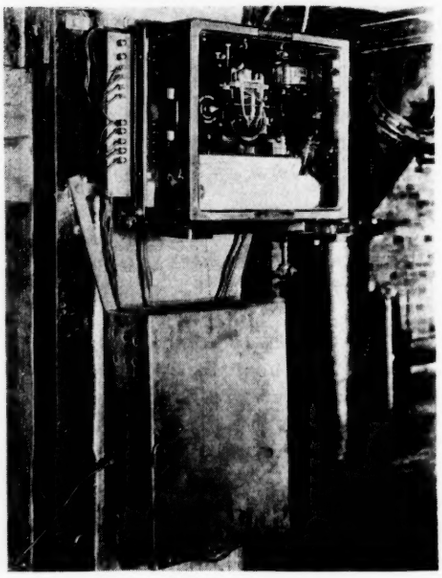


A-Jacks Steam Damper Regulator

The company also makes the A-Jacks over-fire control, designed to maintain the furnace pressure of individual boilers at the point of maximum combustion efficiency, controlling through damper movement the air flow through the fuel bed.

Leeds & Northrup Smoke Recorder

A device which will measure the amount of smoke produced by a boiler has been announced by Leeds & Northrup, 4901 Stenton Ave., Philadelphia, Pa.



Leeds & Northrup Smoke Recorder

It consists of a measuring chamber at the stack or breeching, a recorder at any convenient location and an indicator at the boiler.

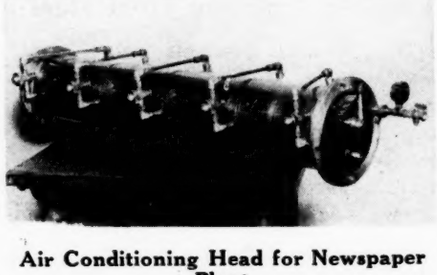
The measuring chamber through which the smoke passes contains a lamp and a specially constructed temperature compensated thermopile. Heat radiated from the lamp passes through the smoke-filled chamber and falls on the thermopile. With a constant heat-source in the lamp, the amount of heat falling on the thermopile is inversely proportional to the density of the smoke. The heat from the lamp which reaches the thermopile causes it to generate a voltage. The measurement of this voltage is the measure of the smoke density.

The recorder is a standard Leeds & Northrup potentiometer recorder. It reads directly in per cent smoke density or Ringelmann chart numbers.

The boiler room indicator is a bank of five lamps. The color of the lamp burning instantly tells the fireman the smoke condition in the stack.

Vapo Systems Atomizing Head

The accompanying photograph shows the atomizing head manufactured by Vapo Systems, 211 W. Wacker Dr., Chicago, Ill. The unit was developed by the mechanical superintendent of the *Chicago Post*, as described in the February issue (page 101) of HEATING AND VENTILATING, and is now available commercially.



Air Conditioning Head for Newspaper Plant

No. 580 Electric Gas Valve

The Time-O-Stat Controls Co., Elkhart, Ind., announces a new electrically-controlled gas valve for use on low-pressure gas-fired equipment, the No. 580 Electric Gas valve. It is adapted for use on industrial and domestic heating plants and various industrial processes where gas is the fuel. In conjunction with a low voltage room thermostat, it provides control on all types of standard domestic gas-fired equipment.

The operating mechanism of the valve consists of a low voltage induction motor which operates through a train of gears to actuate a cam and roller action which in turn lifts the valve off the valve seat. A low voltage magnetic relay which maintains the valve in the open position is part of the construction. This relay is closed mechanically, but when de-energized permits the valve to drop instantaneously to the closed position, thus giving the quick closing action. A manual control device, consisting of a lever operated cam which lifts the valve off the valve seat, is provided so that the valve may be operated in the event of power failure.

The design of the valve is such that it consumes no power when closed and

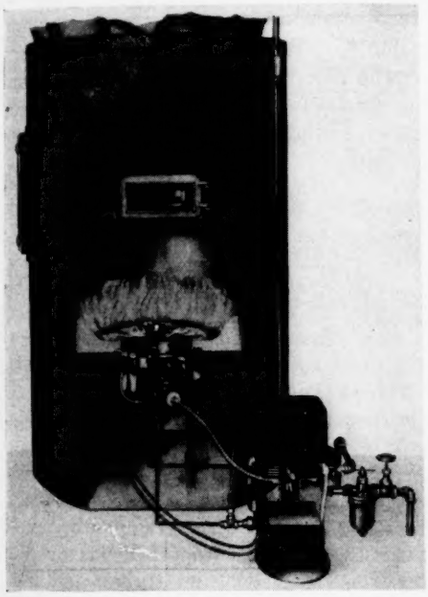
Time-O-Stat No. 580 Electric Gas Valve

New Apparatus and Appliances

only 4 watts while being held open. It closes instantly in the event of power failure. It is furnished in six sizes ranging from 1 in. to 3 in. It can be supplied for 110 volt a. c., either 25 or 60 cycle.

Johnson Centri' Oil Burner

S. T. Johnson Co., Oakland, Calif., announces the Johnson Centri' oil burner, a vertical, centrifugal atomizing gravity type machine, made in one size and two styles, known as GrM and GrA. It will



Johnson Centri' Style GrA Automatic Oil Burner

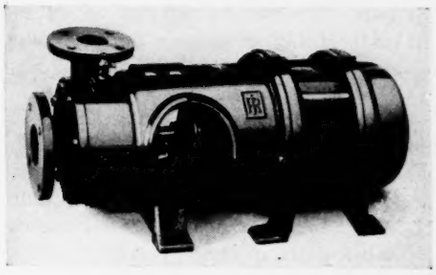
burn from ¾ gal. to 2 gal. per hr. of fuel oil as heavy as No. 3, or Pacific Coast Diesel.

Fuel is automatically supplied to the storage tank either by gravity or an auxiliary pump, atomized by centrifugal force, and mixed with primary or secondary air.

The atomized fuel is then manually ignited if style GrM is being used, or automatically ignited by electric gas pilot, if the GrA has been installed.

Cameron Pump for General Service

A Cameron general service centrifugal pump, designated as the class RV, is announced by Ingersoll-Rand Co., 11 Broadway, New York. Both the pump and the electric motor that drives it are assembled together, producing a compact, light-weight, easily handled unit. This construction reduces the needs for attention by minimizing the number of



Ingersoll-Rand RV Pump

revolving parts and bearings and eliminating the use of a coupling.

The unit is designed for any pumping service requiring a small or medium capacity unit for operation against moderate heads. It is suitable for such applications as circulating and cooling systems, standpipe and water supply systems.

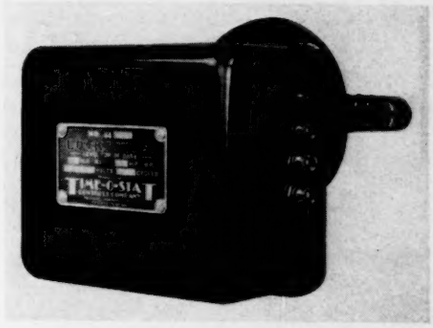
Cook Electric Vapor Motor

Cook Electric Co., 2700 Southport Ave., Chicago, has placed on the market the Cook electric vapor motor for controlling dampers, valves and shutters on heating, ventilating and air conditioning appliances.

Electric current is supplied to the heating element through a thermostat or other current-controlling device. The heat generated vaporizes a small quantity of liquid in the bulb. The vapor, in expanding, drives the remaining liquid out of the vaporizing bulb into the housing, forcing the flexible bellows to contract. This contraction moves the drive shaft through its stroke. The length of stroke and power developed are variable over a wide range by the use of bellows of the proper diameter and length, and a vaporizing bulb of the proper size. The timing can be varied by varying the heating element and the volatile liquid.

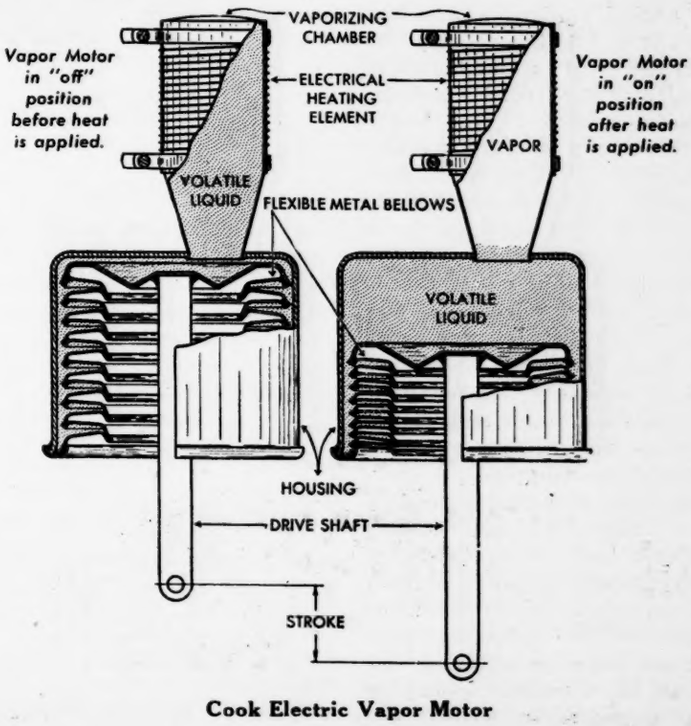
Time-O-Stat No. 44 Lockswitch

The Time-O-Stat Controls Co., Elkhart, Ind., announces the No. 44 Lockswitch, a primary sequence control and safety device for use on fully automatic, power-driven oil burners. This new con-



No. 44 Lock-switch

trol incorporates the functions of the Series 77 and 88 Lockswitches and Series 48 Stackswitches in a single unit. The control circuit of the Lockswitch is low voltage, permitting the use of a low voltage room thermostat and limit control. It is adaptable for electric spark, expanding flame or combination gas-electric ignition. Only a room thermostat or other operating control is required in addition to the Lockswitch to govern the complete operation of the burner. The switch may be used with such additional auxiliary equipment as an oil valve, gas-ignition valve, low water cut-off or limit control.

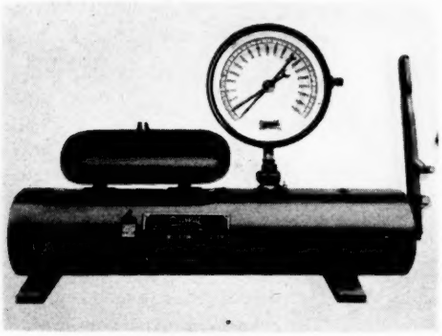


Cook Electric Vapor Motor

New Apparatus and Appliances

Portable Machine for Testing Welds

Oxweld Acetylene Co., 30 East 42nd St., New York, announces the Oxweld portable tensile testing machine, designed to facilitate the testing of welds in the field or shop. The machine weighs 165 lb. and measures 28 in. in overall length and 6¾ in. in maximum diameter, and consists of a tubular compression member with a set of grips in the head and a hydraulic cylinder block in its base. The cylinder block contains a communicating pump and cylinder directly machined into a single block, and the cylinder pressure operates a piston carrying a second set of grips.



Oxweld Portable Tensile Testing Machine

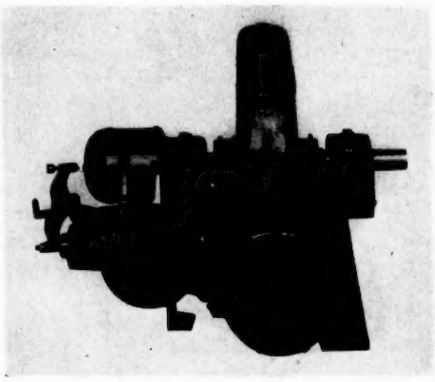
The specimen to be tested is placed between the jaws, which have spring grips. The release valve is closed and the pump handle, applied at the end of the cylinder, is moved back and forth. A set of conical blocks has also been constructed to fit into the machine head in place of the grips so that the standard ½ in. diameter round specimens may be tested if desired. The load is measured directly in pounds per square inch by a suitable, calibrated pressure gauge actuated by the pressure in the cylinder. The gauge is one of the essential parts of the apparatus. When a test is finished, the pressure may be released by a valve and the piston may be returned to its original position by using the pump handle as a lever.

This machine makes it possible to secure a tensile test result immediately after welds are made. This is particularly important in connection with qualification tests for determining welders' ability. It also facilitates making periodic check tests of the operators and in many cases provides a ready means for testing sections cut at random by the inspector from completed work. Industrial and power plant piping contractors and all industries employing welding as a production method will find this machine of service as an aid in maintaining procedure control standards.

G. E. Announces Another Small Turbine

General Electric Co., Schenectady, N. Y., has announced another small, mechanical-drive steam turbine, designated Type D-58, for driving fans, pumps, and similar industrial equipment. The new turbine is designed for operation at steam pressures up to 250 lb. and speeds between 1200 and 4000 r.p.m., with capacities up to approximately 250 hp., and is built only as a single-stage machine.

By limiting the range of conditions under which this turbine will be expected to operate it has been possible to decrease the length and width, making it a compact unit with a considerable saving in weight. The turbine is supported at the center line to permit expansion without affecting the shaft alignment. It is equipped with speed regulating and emergency governors and is fitted with carbon shaft packing. Pipe connections are made to the lower half of the turbine to facilitate opening for inspection.



G-E Type D-58 Steam Turbine

Combustioneer Furnastoker

A line of stokers, suitable for steam or hot water boilers or warm-air furnaces, is being sold by Combustioneer, Inc., Goshen, Ind. These units are designed for the average home, small store buildings, or two or three apartment buildings. The complete system consists of four parts; the stoker, which is a complete unit consisting of a retort, automatic coal feed, hopper, forced draft fan and electric motor; a room thermostat; limit control, and stoker switch.

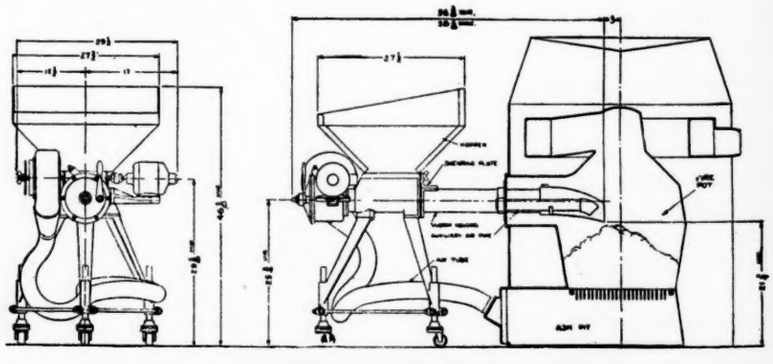
The unit is sold under the name of Furnastoker. It can be installed in any heating plant by removing the grates and inserting the furnace stoker retort through the ash door, allowing the retort to replace the removed grates, and filling in the space between the sidewalls of the ash pit and retort with cinders or sand, and sealing the ash door opening. The unit is designed to burn 1¼ in. to 2 in. bituminous mine screenings or washed pea coal. The ashes are fused into a compact clinker which is removed as accumulated with tongs supplied with the stoker.

The unit has a capacity of 1700 sq. in. of warm-air leader pipe, 1100 sq. ft. of steam radiation, or 1760 sq. ft. of water radiation.

Pease Introduces Junior Sheet Dryer

The Pease Junior sheet dryer, manufactured by The C. F. Pease Co., 813 North Franklin St., Chicago, Ill., is an inexpensive dryer for moderate size blueprints, negatives, blue and brown line prints up to 24 in. wide. When a chromium-plated cylinder is used, it is particularly adapted for drying photo prints.

Prints are fed into the dryer over a brass scraper rod and up an inclined feed table which drains the water away from the drying drum and prevents steam pockets and creased prints. All surplus water is collected in an adjustable drip pan with drain plug located directly beneath the feed table and this pan can be raised or lowered as required for handling either long or short prints. After drying, prints are automatically returned into an adjustable tray at the front of the machine and when especially long prints are being run, the tray can be pushed back out of the way.



Combustioneer Furnastoker

With the Manufacturers

Steam Heating Equipment Manufacturers' Association Elects Officers

At its annual meeting in Chicago, the Steam Heating Equipment Manufacturers' Association, comprising more than 80% of the steam heating equipment manufacturers throughout the country, re-elected the following officers and directors for the coming year: President, E. K. Lanning, Warren Webster & Co.; vice-president, J. C. Matchett, Illinois Engineering Co.; treasurer, W. E. Barnes, Barnes & Jones; secretary, E. J. Ritchie, Sarco Co., Inc. Dirctors: W. E. Barnes, J. C. Matchett, E. K. Lanning, E. J. Ritchie, A. D. Rose, W. K. Simpson, R. N. Trane.

General Electric Takes Over Control Company

The Penn Heat Control Company, a new corporation in which the General Electric Company has a controlling interest, has been formed to take over all assets of the Penn Heat Control Corp., Philadelphia, Pa. The new company will continue and expand the work previously done by the Penn Heat Control Corporation.

The new corporation will retain the personnel and organization of the Penn Heat Control Corporation as the bas's for its operation.

Unused Sizes Found in Survey of Steel Heating Boiler Industry

According to a survey made by the Division of Simplified Practice, Bureau of Standards, for the Steel Heating Boiler Institute, 84% of the low pressure steel heating boilers shipped during 1930 were of only 63 ratings. In other words, 84% of the shipments were in only 20% of the total variety of sizes produced by the industry. There were no shipments of either smokeless or direct draft type boilers of 90 ratings, and over 28% of the sizes in which the two most popular kinds of boilers are made produced no business during 1930.

The survey was made by the bureau at the request of the institute which is composed of the majority of steel heating boiler manufacturers. Thirty-six manufacturers cooperated, of which 22 returned filled-in questionnaires. The 21 plants included in the survey produced 7805 boilers during 1930, over 90% of the output of the steel heating boiler industry.

Compact type welded boilers lead in production with 76.8% of the total shipments. The remaining 23.2% is divided almost equally between riveted and welded boilers of the barrel firebox type. Shipments of the riveted boilers of this type amounted to 11.4% and the welded 11.3% of the total shipments.

Company Formed to Supply Contractors with Accounting and Bookkeeping Supplies

Organized in the interests of the plumbing and heating industries, the Plumbing and Heating Contractors Supply Company has been formed under the laws of Illinois to supply contractors with accounting, estimating and bookkeeping supplies and forms especially designed for the purpose. Headquarters is at Suite 1700, 29 Quincy St., Chicago.

A. Wallace & Company and **The Illinois Engineering Company** announce the removal of their offices from 2971 Irving St., to 3060 West Thirty-Second Ave., Denver, Colo.

H. B. Smith Co., Westfield, Mass., announces the appointment of Grant Pierce, formerly head of the National Radiator Co., Providence, R. I., as vice-president in charge of sales.

United District Heating, Inc., announces the removal of its offices to 4400 Perkins Ave., Cleveland, Ohio.

The American Propeller Co., formerly of Baltimore, Md., announces the removal of its entire plant to South Bend, Ind.

Heating Apparatus Co., New York, manufacturers' agents and distributors, announces the opening of its new office and show room at 53 West Broadway.

Minneapolis-Honeywell Regulator Co., Minneapolis, Minn., announces the election of A. I. Wallace, vice-president of the Time-O-Stat Controls Company, as a vice-president of its company, following the recent merger of the two companies.

Simplex Oil Heating Corp., New York, announces the appointment of G. H. Rittenhouse as its sales manager. Mr. Rittenhouse has been directly connected with the sale of oil burners for seven years.

Unit Ventilation Co., Inc., 18-34-128th St., College Point, New York, announces that Alfred A. Driggs, formerly district manager for the Buckeye Blower Company, is now associated with its company.

American Machine Products Co., Marshalltown, Ia., announces the appointment of G. A. Voorhees as its heating engineer. Mr. Voorhees is a member of the A.S.H.V.E. National Warm Air Heating Association and A.S.M.E.

The Wickes Boiler Co., Heating Division, Saginaw, Mich., announces the appointment of the Kilner-Mills Co., 3-266 General Motors Bldg., Detroit, as its district representatives.

The Spencer Thermostat Co., Cambridge, Mass., and the **General Plate Co.**, Attleboro, Mass., have just combined and will be known jointly as the **Metals and Controls Corporation.** They both will continue as separate units of this combined body. Offices of the Spencer Company have been moved to Attleboro, but the entire personnel of each organization will remain unchanged. The merger will give the two companies greater research, manufacturing and sales facilities in their kindred fields.

United States Radiator Corp., Detroit, Mich., announces the transfer of H. N. Booth, formerly district manager of the metropolitan area of New York, to the general offices at Detroit and his appointment as vice-president in charge of the sales department. R. H. Mills has been named Mr. Booth's successor.

With the Manufacturers

Revere Copper and Brass Inc., Rome, N. Y., announces the removal of its executive, general sales and advertising departments from that city to 230 Park Ave., New York. The treasurer's office and general accounting department will remain in Rome.

Spencer Heater Co., Williamsport, Pa., announces the following additions to its selling organization under E. A. MacDonald, district manager; S. N. Foster, Augusta, Me., has been appointed Maine representative; Charles D. Morrissey, 216 Tremont St., Boston, for the Metropolitan Boston area; J. H. Kriebel, under G. H. Hertz, Jr., district manager, Otis Bldg., Philadelphia, for the Metropolitan Philadelphia area.

Rome Radiation Co., a division of **Revere Copper and Brass Inc.**, Rome, N. Y., announces the establishment of its own sales organization to promote and continue the sale of Robras radiators. For several years past the Rome Radiation Company manufactured these radiators, which were sold by the Rome Brass Radiator Corp., New York. The selling agreement between these two organizations has recently been discontinued.

The Duriron Co., Inc., Dayton, Ohio, recently elected the following officers: President, William E. Hall; vice-presidents, Dudley H. Miller and John R. Pitman; secretary, Robert C. Schenck; treasurer, E. B. Thacker. Mr. Miller was appointed general manager, and Mr. Hall succeeds P. D. Schenck, the late president and founder of the company.

The Bishop & Babcock Sales Co., 4901 Hamilton Ave., N. E., Cleveland, Ohio, announces the appointment of the James E. Degan Co., 2160 Franklin St., Detroit, Mich., as its district sales representative. Fred I. Powers, Bozeman, Mont., has been appointed district sales representative for Montana and upper Wyoming, and M. A. Disney, of the Heating Equipment Co., 3543 Broadway, Kansas City, district representative for the state of Kansas and northwestern Missouri.

The Surface Combustion Co., 2375 Dorr St., Toledo, Ohio, announces the appointment of the Eastern Service Co., Boston, Mass., as the New England distributor for its equipment. The territory covered by this arrangement includes the states of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut.

The Committee of Ten has established general administrative headquarters and **The National Coal Association** has established its Western office at 307 N. Michigan Ave., Chicago, Ill.

Republic Radiator Co. Baltimore, Md., is distributing to engineers and estimators a 9 in. x 12 in. card with radiator ratings listed under heights and number of tubes, vertical lines dividing the various heights under which the number of tubes are sub-classified. Horizontal lines divide the number of sections and the combination of height and number of sections will give the capacity of the radiator. Use of the card makes it extremely easy to select a radiator of a desired size which will also meet the desired capacity without the necessity of turning over handbook pages. The card is suitable for radiation of all makes. Copies can be secured on request through the designer, Albert H. Dyett, Evins F. Glore & Son, Inc., New York, representatives of the Company, Grand Central Terminal.

Illinois Stoker Co., Alton, Ill., announces the appointment of The Ashmead-Danks Co., Room 515 Rockefeller Bldg., Cleveland, Ohio, to handle its equipment in that city.

The W. M. Chace Valve Co., Detroit, Mich., announces the appointment of the Melchior, Armstrong, Dessau Co., 116 Broad St., New York, as European sales agents, covering the British Isles and most of Continental Europe.

The Penn Electric Switch Co., Des Moines, Ia., has appointed the Pennsylvania Distributing Co., 2401 Chestnut St., Philadelphia, Pa., as exclusive distributor in that territory for its line of automatic controls, and E. C. Hansen, operating as the Penn Electric Switch Distributing Co., 1328 N. 12th St., Milwaukee, Wisc., to cover Wisconsin and upper Michigan.

Weil Pump Co., 325 W. Huron St., Chicago, Ill., announces the appointment of Layman-Rummel Co., 303 Westinghouse Building, Pittsburgh, Pa., as its distributors and sales engineers in that territory.

Fix-Lippman Company has been organized to take over the inventory, equipment and good-will of the Kellogg-Mackay Co., 5259 Northwest Highway, Chicago, the latter company now being in the process of liquidation. Fred. W. Fix, Jr., Orville S. Lippman, and John L. Fix, formerly connected with Kellogg-Mackay, will manage the new concern.

The Industrial Pipe & Supply Company is the new corporate name of Morris M. Fineberg & Co., Boston, Mass. M. M. Fineberg is president and treasurer and William M. Chance is sales manager.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912, OF HEATING AND VENTILATING, published monthly at New York, N. Y., for April 1, 1931.

State of New York, County of New York, ss.:

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Cliff W. Presdee, who, having been duly sworn according to law, deposes and says that he is the Business Manager of Heating and Ventilating and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, National Trade Journals, Inc., 521 Fifth Ave., New York City.
Editor, C. H. B. Hotchkiss, 521 Fifth Ave., New York City.
Managing Editor, Clifford Strock, 521 Fifth Ave., New York City.
Business Manager, Cliff W. Presdee, 521 Fifth Ave., New York City.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

National Trade Journals, Inc., 521 Fifth Avenue, New York City; Maynard S. Bird, 63 Wall Street, New York City; H. Content & Co., 111 Broadway, New York City; Foster & Adams, 71 Broadway, New York City; Goldman Sachs & Co., 30 Pine Street, New York City; H. Hentz & Co., 60 Beaver Street, New York City; Hornblower & Weeks, 42 Broadway, New York City; F. B. Keech & Co., 52 Broadway, New York City; H. J. Redfield, 521 Fifth Avenue, New York City; Edward T. Rocke, 527 Fifth Avenue, New York City; L. F. Rothschild & Co., 120 Broadway, New York City; C. Stanley Taylor, 40 East 49th Street, New York City; Warwick & Co., 120 Broadway, New York City; James H. Weldon, Jr., 30 Federal Street, Boston, Mass.; Winfred A. Williamson, c/o Tucker Hunter Dulin & Co., Hunter-Dulin Building, San Francisco, Calif.; John T. Wilson, 24 Sunderland Ave., Rutherford, N. J.; Rupert T. Zickl, c/o Bond & Goodwin, 63 Wall Street, New York City.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are:

None.

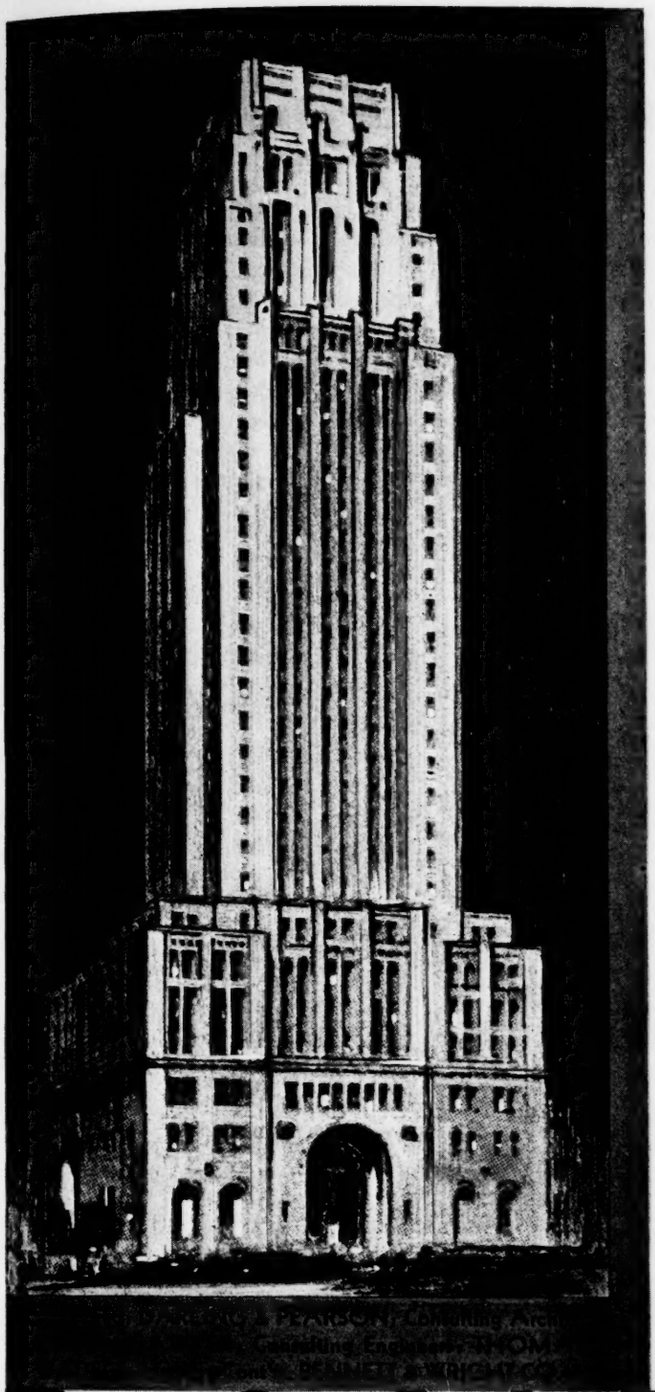
4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner: and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

CLIFF W. PRESDEE, Business Manager.

Sworn to and subscribed before me this 31st day of March, 1931.

MADELINE DIETRICH.

Notary Public, Bronx County.
(Commission expires, March 30, 1933.)
Bronx County Clerk's No. 90.
New York County Clerk's No. 207.
Register's No. 3D125.



Toronto's tallest sky scraper

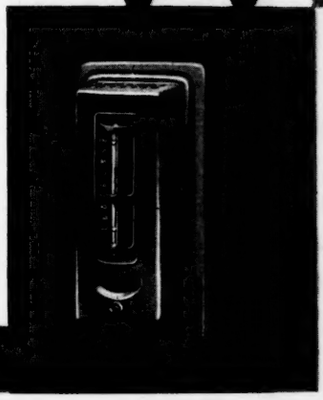
THE CANADIAN BANK OF COMMERCE BLDG.

The Powers System of Automatic Temperature Control was selected to regulate the ventilating system and the direct radiation in the main banking floors of this prominent building. • • • Powers Control often costs more, but it's worth more—because: its longer life and greater dependability insure a maximum return on the investment in heat control.

POWERS

Powers Thermostats Are Better

Because—they often give 15 to 20 years of Accurate Control without repairs of any kind—they need no annual overhauling.



THE POWERS REGULATOR CO.

40 Years of Specialization in Temperature Control

CHICAGO: 2720 Greenview Avenue
NEW YORK CITY: 231 East 46th Street

Offices in 41 Other Cities

THE CANADIAN POWERS REGULATOR CO., LTD.
106 Lombard Street, Toronto, Ontario

Degree Days and Unit Fuel Consumption in Typical Cities for March

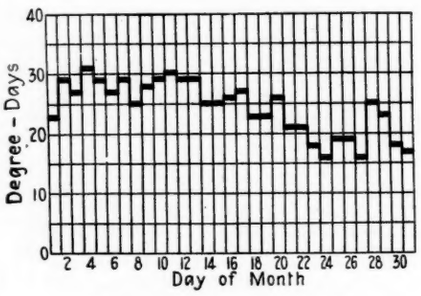
UNIT fuel consumption figures given below must be corrected for efficiency, heat content of fuel other than that listed below, for radiation emitting other than 240 B.t.u. per hr., and for radiation calculated on a basis of other than zero outside to 70° inside.

Coal is assumed as having a heat content of 12,000 B.t.u. per lb., gas, 1000 B.t.u. per cu.ft. and oil 140,000 B.t.u. per gal. To correct for other heating values, multiply the fuel consumption listed under the charts by the standard heat content just listed, and divide by the heat content of the fuel actually being used in the installation being calculated.

For radiation installed for any other outside temperatures than zero, multiply the fuel consumption given under the charts by 70°, divided by the quantity (70 minus the outside temperature used).

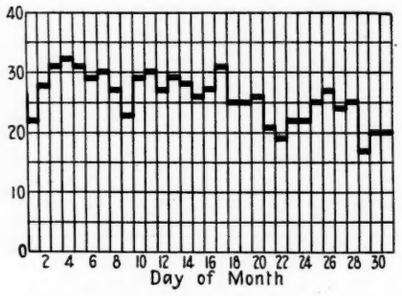
To correct for efficiency, divide the fuel consumption by the efficiency of the heating installation.

For water radiation, multiply the fuel consumption which is given for steam radiation by 5/8.



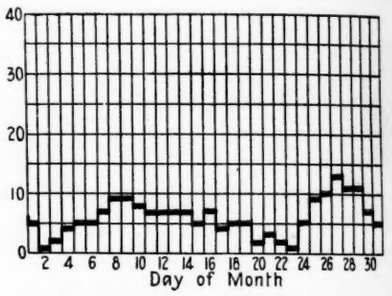
New York, March, 1931

Degree Days 758—to Date, 4443
Lb. of Coal per Sq. Ft. of Radiation for this Month, 6.064
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.52
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 72.77
(See Footnote)



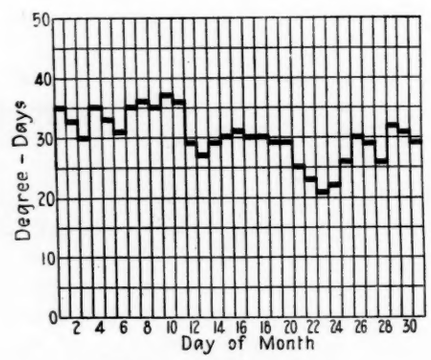
Boston, March, 1931

Degree Days 798—to Date, 4808
Lb. of Coal per Sq. Ft. of Radiation for this Month, 6.384
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.547
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 76.61
(See Footnote)



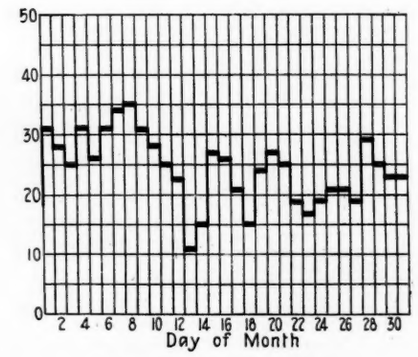
San Francisco, March, 1931

Degree Days 188—to Date, 1613
Lb. of Coal per Sq. Ft. of Radiation for this Month, 1.504
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.129
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 18.05
(See Footnote)



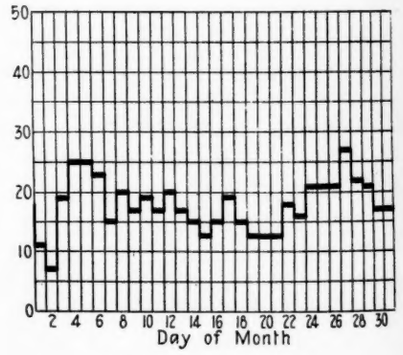
Chicago, March, 1931

Degree Days 934—to Date, 5063
Lb. of Coal per Sq. Ft. of Radiation for this Month, 7.472
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.640
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 89.66
(See Footnote)



St. Louis, March, 1931

Degree Days 755—to Date, 3987
Lb. of Coal per Sq. Ft. of Radiation for this Month, 6.040
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.517
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 72.48
(See Footnote)

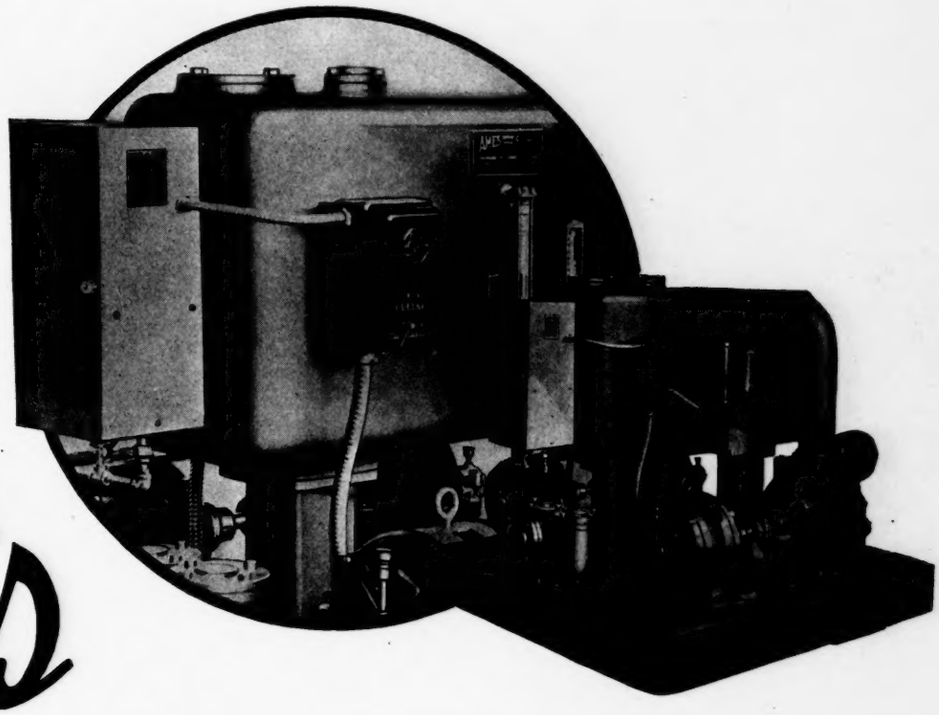


Seattle, March, 1931

Degree Days 552—to Date, 3615
Lb. of Coal per Sq. Ft. of Radiation for this Month, 4.416
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.379
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 52.99
(See Footnote)

Fuel consumption figures must be corrected for local conditions as explained above.

(Continued on Page 118)



Facts

FLEXIBILITY OF OPERATION

DISTINCT ADVANTAGE IN A VACUUM HEATING PUMP

FLEXIBILITY of Operation adapts a vacuum heating pump to the needs of the heating system.

AMES PUMPS are regularly provided with Automatic Vacuum Control and Float Control.

Illustration shows position of switches for Vacuum Control—combined with Float Control.

For operation with Float Control only (usually during the night period). Vacuum Control Switch is cut out and Starter Switch left in position shown above.

CONTINUOUS OPERATION is also attainable—by placing Starter Switch on "Hand" and Vacuum Switch on "Off" position. *This is a distinctive feature of "AMES" standard equipment.*

This advertisement is the fourth of the series. Eight more will follow.

Write for Bulletin No. 522 and 532

AMES PUMP COMPANY, Inc.

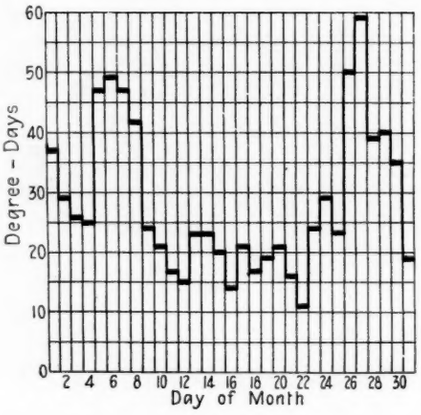
30 Church Street New York City

DIVISION OF

AMERICAN LOCOMOTIVE COMPANY

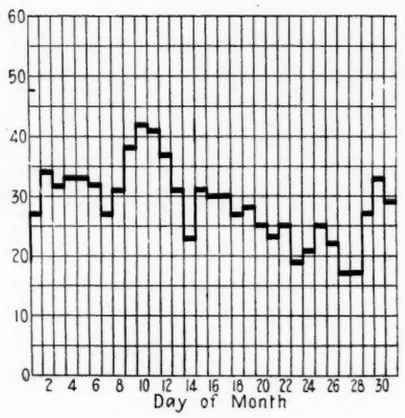
Degree Days for March, 1931

(Continued from Page 116)



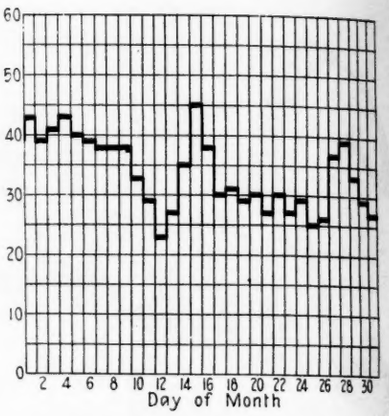
Denver, March, 1931

Degree Days 883—to Date, 4824
Lb. of Coal per Sq. Ft. of Radiation for this Month, 7.064
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.606
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 84.77
(See Footnote Page 116)



Pittsburgh, March, 1931

Degree Days 855—to Date, 4829
Lb. of Coal per Sq. Ft. of Radiation for this Month, 6.840
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.586
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 82.08
(See Footnote Page 116)



Minneapolis, March, 1931

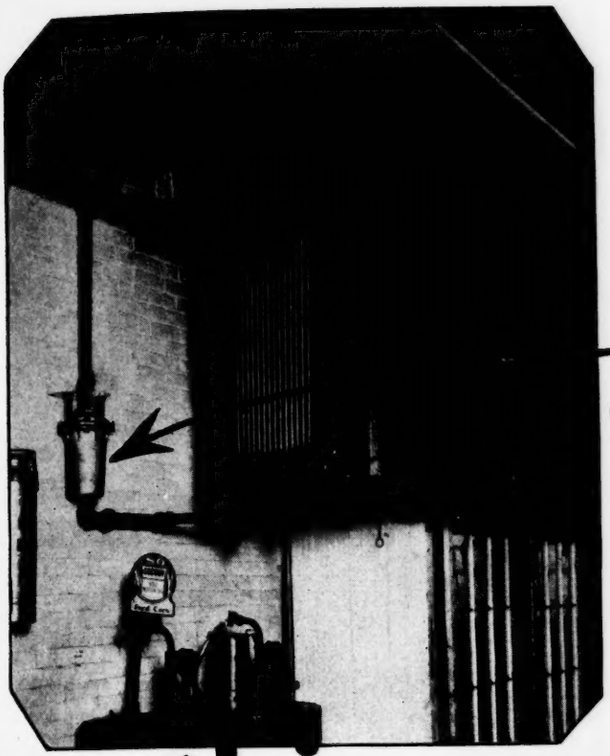
Degree Days 1038—to Date, 6020
Lb. of Coal per Sq. Ft. of Radiation for this Month, 8.304
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.716
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 99.65
(See Footnote Page 116)

	Los Angeles	Baltimore	Philadelphia	New Orleans	Atlanta	Cleveland	Cincinnati	Detroit
Degree Days	56	713	703	237	568	964	833	1259
Degree Days to Date	622	3915	4044	1382	3175	4981	4490	5608
Lb. of Coal per Sq. Ft. of Radiation for March, 1931	0.448	5.704	5.624	1.896	4.544	7.712	6.664	10.072
Gal. of Oil per Sq. Ft. of Radiation for March, 1931	0.038	0.489	0.482	0.162	0.390	0.661	0.572	0.864
Cu. Ft. of Gas per Sq. Ft. of Radiation for March, 1931	5.38	68.45	67.49	22.75	54.53	92.54	79.97	120.86

(See Footnote Page 116)

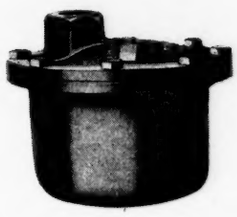
	Buffalo	Birmingham	Indianapolis	Memphis	Des Moines	Kansas City	Louisville	Galveston
Degree Days	1008	492	883	554	900	801	773	278
Degree Days to Date	5577	2734	4730	3033	5029	4068	4120	1342
Lb. of Coal per Sq. Ft. of Radiation for March, 1931	8.064	3.936	7.064	4.432	7.200	6.408	6.184	2.224
Gal. of Oil per Sq. Ft. of Radiation for March, 1931	0.691	0.337	0.606	0.380	0.617	0.549	0.530	0.191
Cu. Ft. of Gas per Sq. Ft. of Radiation for March, 1931	96.77	47.23	84.77	53.18	86.40	76.90	74.21	26.69

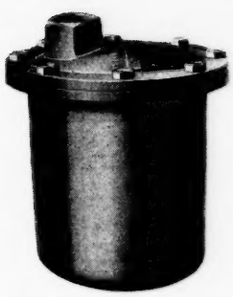
(See Footnote Page 116)



ARMSTRONG "INVERTED BUCKET" STEAM TRAP

"the insurance policy" on this unit heater





Two other types of Armstrong Traps commonly used for draining heaters are shown here

THE Armstrong Steam Trap on this unit heater in the garage of the American Palace Laundry, Buffalo, New York, is "assurance" that it will operate at its highest efficiency at all times.

Armstrong Traps are ideal for heating service since they discharge air entrained in the system as well as condensate. They are light and compact enough to be supported by the connecting pipes, yet they have large capacity without leakage of steam. Made in sizes and types for pressures to 1350 lbs. and temperatures to 750° F.

District Representatives in 42 Cities of the United States and Canada are available both for new installation work or to service present equipment.

ARMSTRONG MACHINE WORKS

Three Rivers, Michigan

846 Maple Street

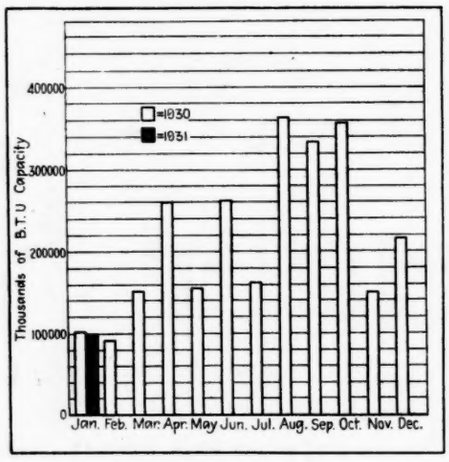
District Representative in 42 Cities

H&V5-Gray

Statistical Service

EIGHT of the charts shown on the following page indicate the amount of money spent for *heating and ventilating equipment in various classes of new buildings.* These figures are based on data supplied by the F. W. Dodge Corporation and multiplied by a factor depending on the type of building. This factor has been determined after consideration of the factors used by the Heating Board of Trade of New York and by C. Stanley Taylor in his Forecast appearing annually in this publication and those determined by survey by the H. & P.C.N.A.

The remaining charts cover the shipments or new orders of various products of the industry. Mechanical stokers, reported last month for the first time, have not been reported again. All of these types of charts are based on data supplied by the Department of Commerce.

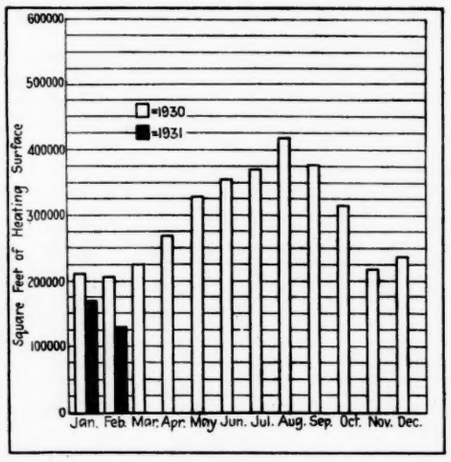


Shipments of Gas-Fired Boilers

(In Thousands of B.t.u. Capacity)

As Reported by 8 Manufacturers Representing 75% of the Industry

January, 1931, 98,397; January, 1930, 100,030; decrease over last year, 1.6%.

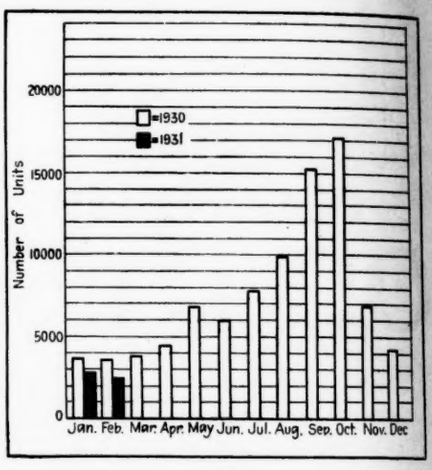


New Orders for Steel Heating Boilers

(In Square Feet of Heating Surfaces)

As Reported by Firms Making Up the Greater Part of the Industry

February, 1931, 127,367; February, 1930, 212,850; decrease over last year, 40%; total, two months, 1931, 297,274; total, two months, 1930, 427,075; decrease over last year, 30.4%.

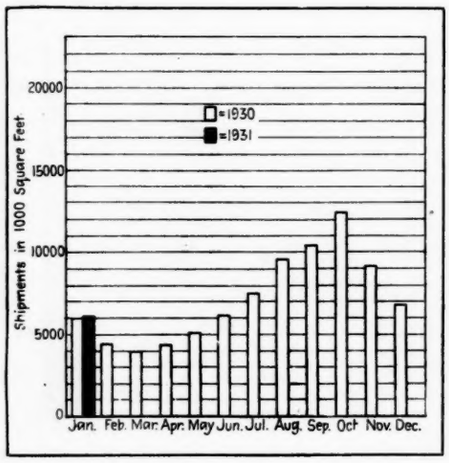


Shipments of Oil Burners

(In Number of Units)

As Reported by 50 Manufacturers Representing 60% of the Industry

February, 1931, 2506; February, 1930, 3475; decrease over last year, 27.9%; total, two months, 1931, 5305; total, two months, 1930, 6997; decrease over last year, 24.2%.

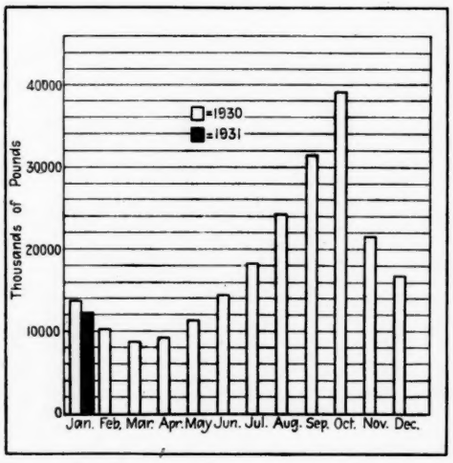


Shipments of Cast Iron Radiators

(In 1000 Square Feet)

As Reported by 15 Manufacturers Representing over 90% of the Industry

January, 1931, 6091; January, 1930, 6047; increase over last year, 7.3%.

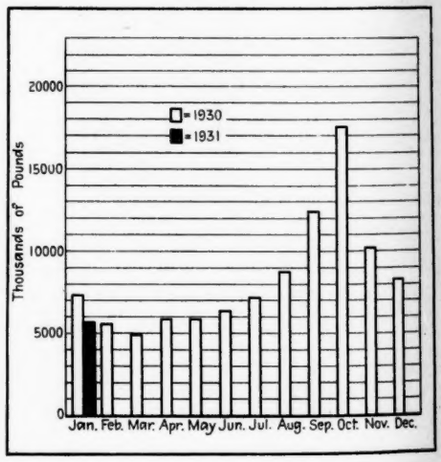


Shipments of Cast Iron Square Boilers

(In Thousands of Pounds)

As Reported by 25 Manufacturers Representing 90% of the Industry

January, 1931, 12,082; January, 1930, 13,836; decrease over last year, 12.7%.

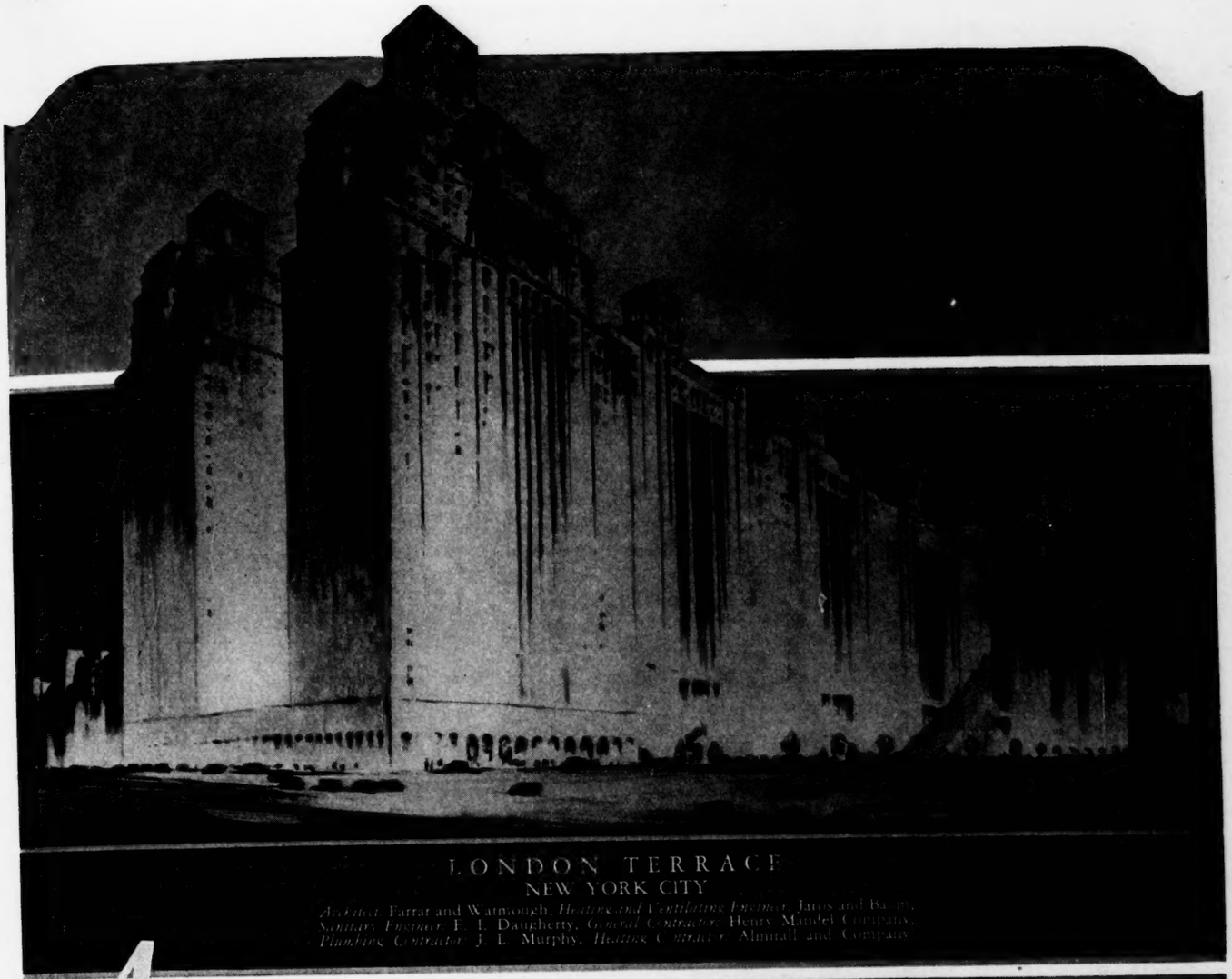


Shipments of Cast Iron Round Boilers

(In Thousands of Pounds)

As Reported by 25 Manufacturers Representing 90% of the Industry

January, 1931, 5724; January, 1930, 7304; decrease over last year, 21.6%.



LONDON TERRACE
NEW YORK CITY
Architect Farrar and Watmough, *Heating and Ventilating Engineer* Jaros and Baum, *Sanitary Engineer* F. I. Daugherty, *General Contractor* Henry Mandel Company, *Plumbing Contractor* J. L. Murphy, *Heating Contractor* Almirall and Company

America's Largest Apartment

PLANNED FOR 100 YEARS OF SERVICE

Superseding a dignified row of houses which has stood for 85 years on West 23rd Street, New York City, the new London Terrace Apartment has been planned for several generations of service—in fact the builders expect it to be economically effective for a hundred years.

This mammoth structure is believed to be the largest apartment building in the world, and undoubtedly is one of the finest and most substantial. Between nine hundred and a thousand households—5,000 to 6,000 people—can be accommodated in its 4,200 rooms. Restaurants, gymnasium, swimming pool, shops and markets—all the requirements of a residential community are provided.

Such an unusual and expensive undertaking must be substantial in every detail. For wrought materials, no compromise of quality could be considered here. The use of NATIONAL Pipe for the major pipe tonnage in this modern, forward-looking enterprise gives additional force to the known character of—

America's Standard Wrought Pipe

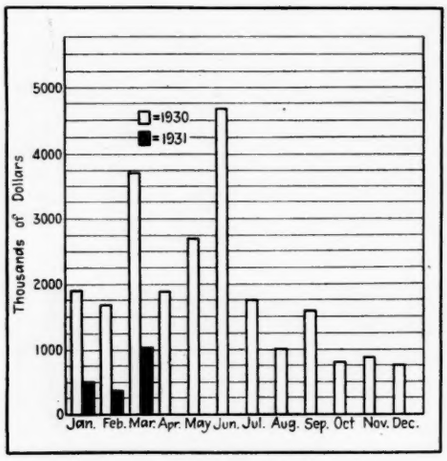
NATIONAL TUBE COMPANY, PITTSBURGH, PA.
Subsidiary of United States Steel Corporation

NATIONAL PIPE

Statistical Service

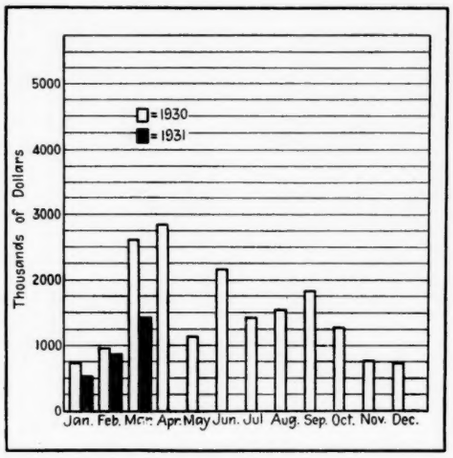
(*Continued from Page* 120)

(Data below refer to value of heating and ventilating equipment only.)



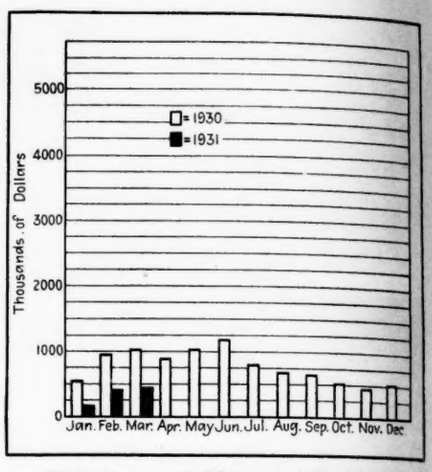
Industrial Buildings

March, 1931, $1,031,000; March, 1930, $3,717,000; decrease over last year, 71.7%; total, three months, 1931, $1,899,000; total, three months, 1930, $7,305,000; decrease over last year, 74%.



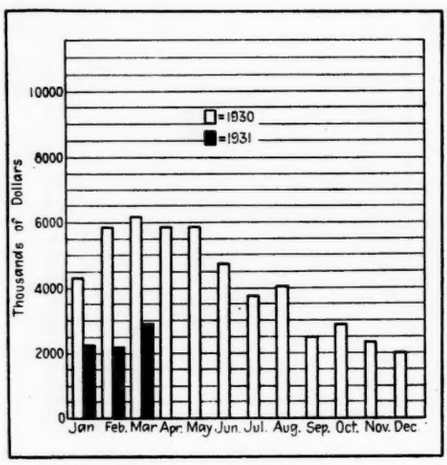
Hospital and Institutional Buildings

March, 1931, $1,435,000; March, 1930, $2,618,000; decrease over last year, 45.2%; total, three months, 1931, $2,817,000; total, three months, 1930, $4,330,000; decrease over last year, 35%.



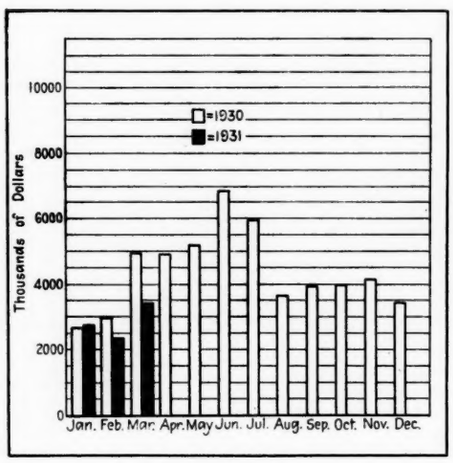
Religious and Memorial Buildings

March, 1931, $425,000; March, 1930, $1,010,000; decrease over last year, 58%; total three months, 1931, $987,000; total, three months, 1930, $2,518,000; decrease over last year 60.4%.



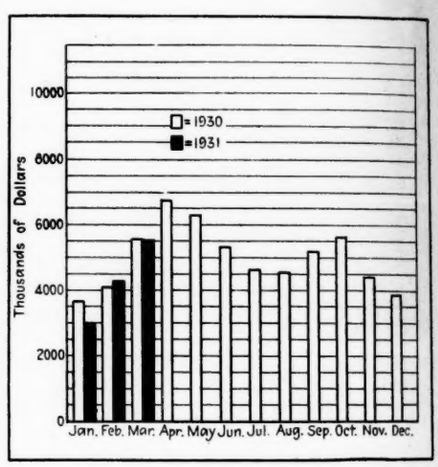
Commercial Buildings

March, 1931, $2,935,000; March, 1930, $6,160,000; decrease over last year, 52.4%; total, three months, 1931, $7,410,000; total, three months, 1930, $17,316,000; decrease over last year, 57.1%.



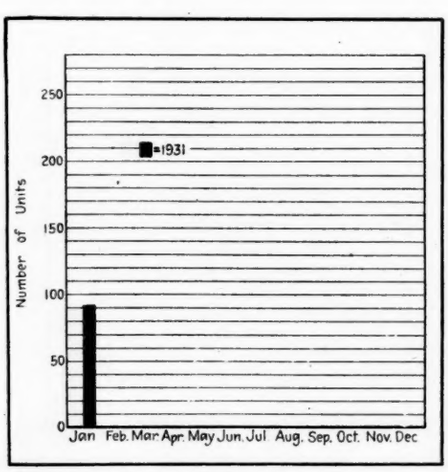
Educational Buildings

March, 1931, $3,405,000; March, 1930, $4,949,000; decrease over last year, 31.3%; total, three months, 1931, $8,458,000; total, three months, 1930, $10,583,000; decrease over last year, 20.1%.



Residential Buildings

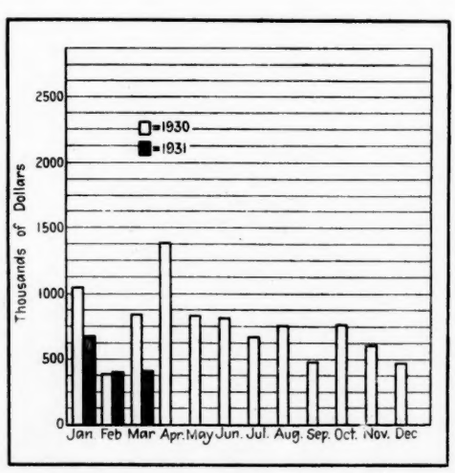
March, 1931, $5,550,000; March, 1930, $5,582,000; decrease over last year, 0.6%; total, three months, 1931, $12,826,000; total, three months, 1930, $13,359,000; decrease over last year, 4%.



Mechanical Stokers for House-Heating

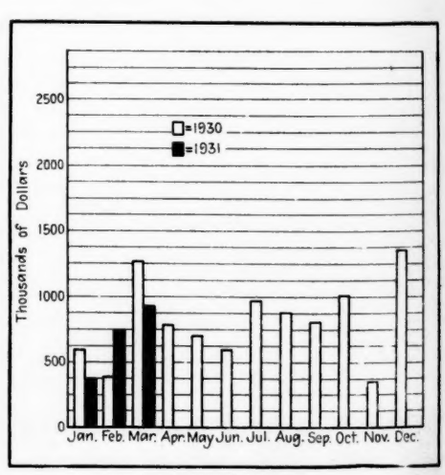
(In Number of Units)

January, 1931, 91; not available for January, 1930.



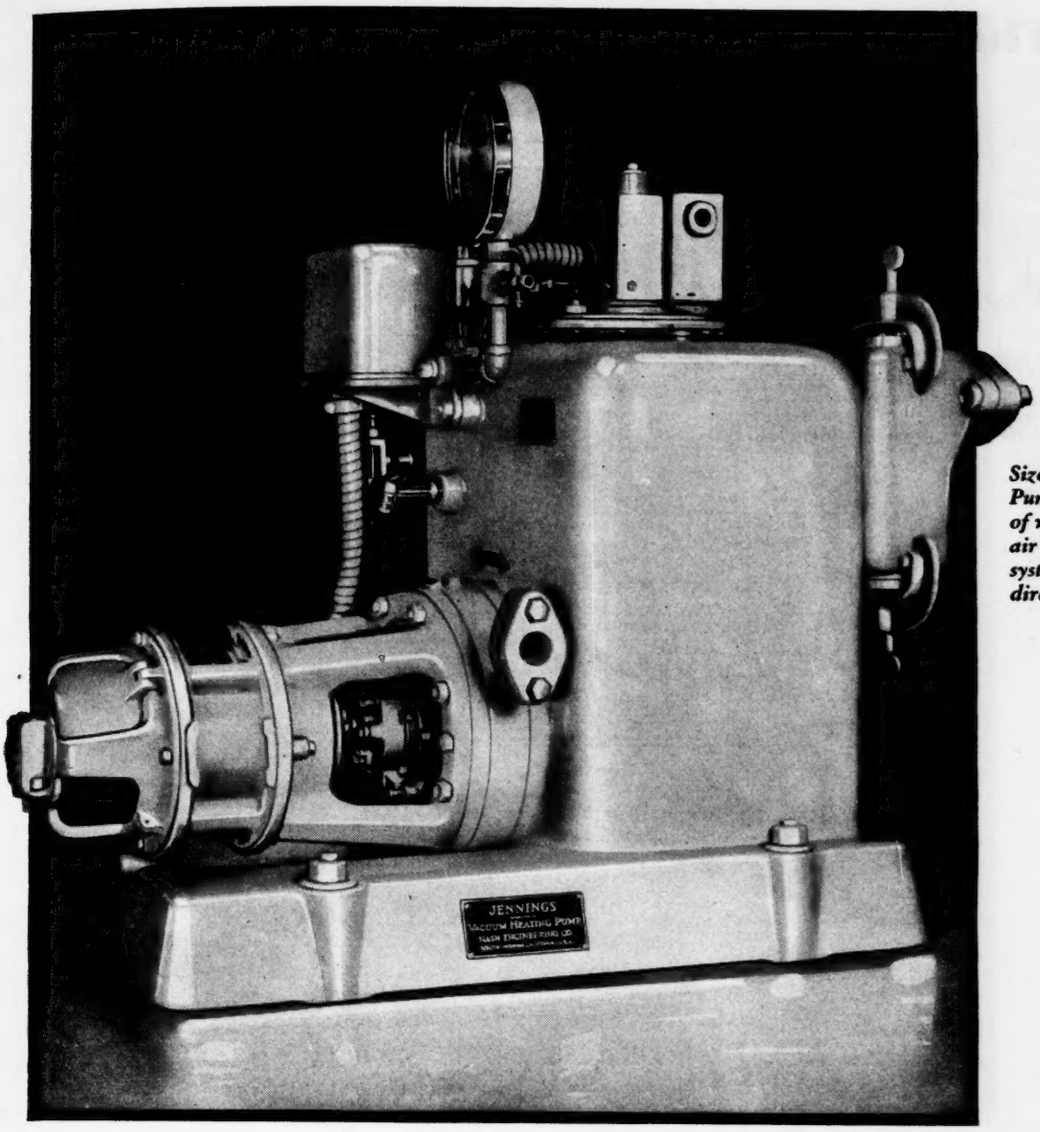
Social and Recreational Buildings

March, 1931, $420,000; March, 1930, $840,000; decrease over last year, 50%; total, three months, 1931, $1,505,000; total, three months, 1930, $2,279,000; decrease over last year, 34%.



Public Buildings

March, 1931, $923,000; March, 1930, $1,273,000; decrease over last year, 27.4%; total, three months, 1931, $2,047,000; total, three months, 1930, $2,264,000; decrease over last year, 9.6%.



Size U Jennings Vacuum Heating Pump with a capacity of 8 g.p.m. of water and 5 cu. ft. per min. of air for return line vacuum heating systems of 5000 sq. ft. equivalent direct radiation.

FOR EFFICIENT OPERATION
of small return line heating systems

SMALL return line heating systems can be given the same efficiency and economy of operation as the heating systems in large buildings by installing the Unit Manifold type of Jennings Vacuum Heating Pump.

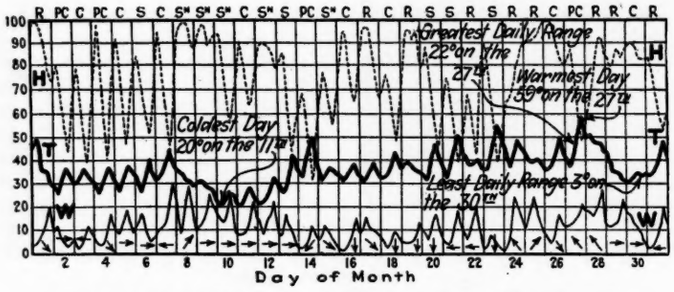
This sturdy, reliable unit is especially designed to serve systems of 5000 sq. ft. of radiation and under. Automatically controlled, it requires little attention. By keeping return lines and radiators free of air and condensation, it permits the system to function perfectly at all times. Noticeable fuel economies result because the boiler, under a constant vacuum, generates steam at a lower pressure and at a lower temperature.

For complete information on the unit Manifold type of Jennings Vacuum Heating Pump, write for Bulletin 87.

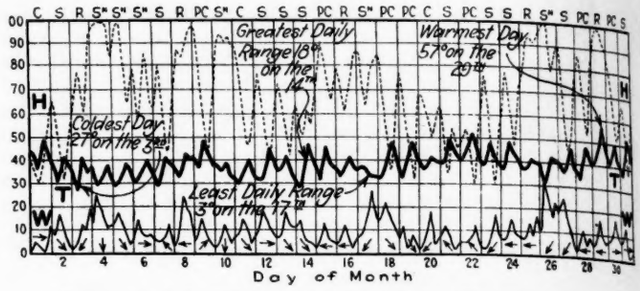
Jennings Pumps

THE NASH ENGINEERING COMPANY, 81 WILSON ROAD, SOUTH NORWALK, CONN.

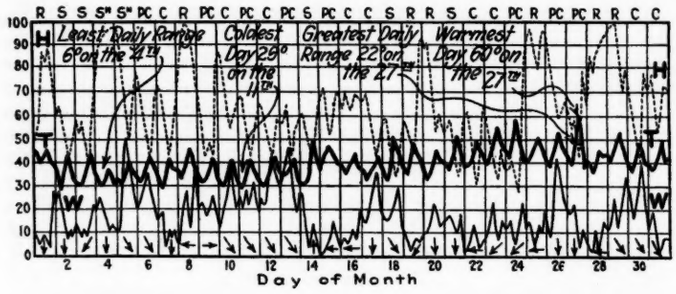
The Weather for March, 1931


Greatest Daily Range 22° on the 27th
Warmest Day 59° on the 27th
Coldest Day 20° on the 11th
Least Daily Range 3° on the 30th
Day of Month

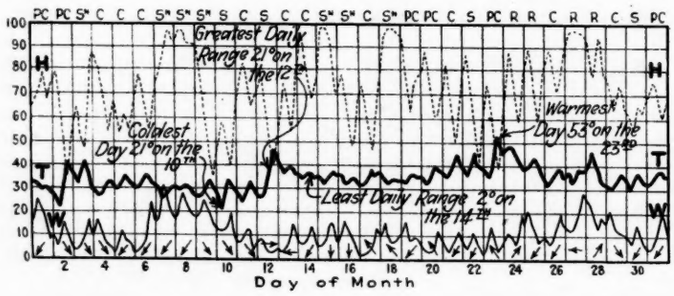
Record of the Weather in Pittsburgh for March, 1931


Greatest Daily Range 18° on the 14th
Warmest Day 57° on the 20th
Coldest Day 27° on the 3rd
Least Daily Range 3° on the 17th
Day of Month

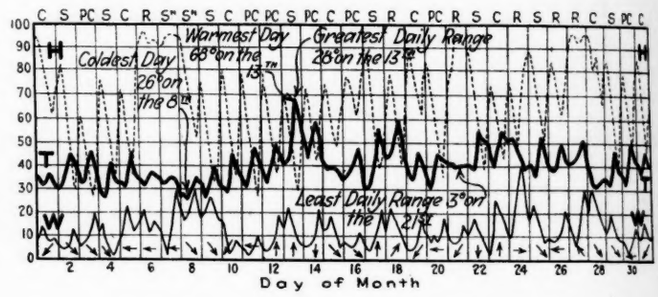
Record of the Weather in Boston for March, 1931


Least Daily Range 6° on the 21st
Coldest Day 29° on the 10th
Greatest Daily Range 22° on the 27th
Warmest Day 60° on the 27th
Day of Month

Record of the Weather in New York for March, 1931
(Hourly Observation of the Relative Humidity Plotted on this Chart.)


Greatest Daily Range 21° on the 12th
Coldest Day 21° on the 19th
Warmest Day 53° on the 23rd
Least Daily Range 2° on the 14th
Day of Month

Record of the Weather in Chicago for March, 1931


Warmest Day 68° on the 13th
Greatest Daily Range 26° on the 13th
Coldest Day 26° on the 8th
Least Daily Range 3° on the 21st
Day of Month

Record of the Weather in St. Louis for March, 1931

	New York	Boston	Pittsburgh	Chicago	St. Louis
Highest temperature, deg. F.	60	57	59	53	68
Date of highest temperature	27	29	27	23	13
Lowest temperature, deg. F.	29	27	20	21	26
Date of lowest temperature	11	3	11	10	8
Greatest daily range, deg. F.	22	18	22	21	28
Date of greatest daily range	27	14	27	12	13
Least daily range, deg. F.	6	3	3	2	3
Date of least daily range	4	17	30	14	21
Mean temperature for month, deg. F.	40.5	39.3	36.4	34.8	40.6
Normal mean temperature for month, deg. F.	37.7	35.5	39.6	35.3	44.1
Total precipitation, this month, inches	4.74	4.66	2.48	3.33	2.39
Total snowfall, this month, inches	1.0	7.3	3.4	19.8	2.7
Normal precipitation, this month, inches	3.64	3.57	3.03	2.58	3.38
Total wind movement, this month, miles	11,640	6668	7141	7815	8682
Average hourly wind velocity, miles	15.6	9.0	9.6	10.5	11.7
Prevailing direction of wind	N.W.	N.W.	W.	N.E.	N.W.
Number of clear days	4	8	1	4	7
Number of partly cloudy days	8	11	7	7	10
Number of cloudy days	19	12	23	20	14
Number of days with precipitation	11	12	16	12	9
Number of days with snowfall	3	5	6	5	2
Snow on ground, at end of month	None	None	None	None	None

Plotted from records especially compiled for HEATING AND VENTILATING by the United States Weather Bureau.
Heavy lines indicate temperatures in degrees F. Light lines indicate wind in miles per hour.
Broken lines indicate humidity in percentage from readings at 8 A.M., 12 M., and 8 P.M.
S—clear, PC—partly cloudy, C—cloudy, R—rain, Sn—snow. Arrows fly with prevailing directions of wind.

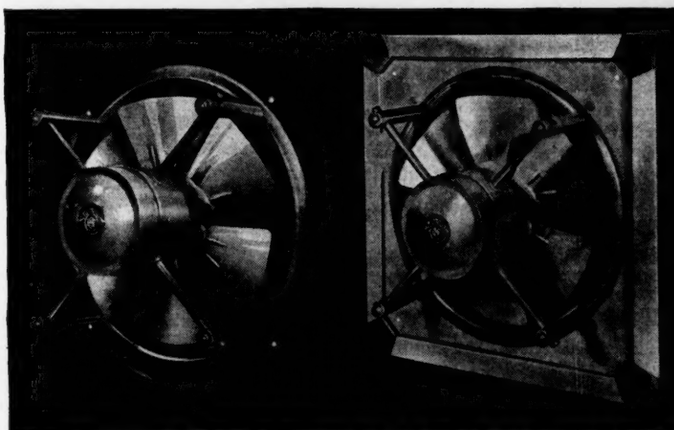
WE CONSULTED SCORES OF CONTRACTORS...

then we designed this Sturtevant Fan

Before making a single drawing for this new Sturtevant Propeller Fan, we sent investigators to interview men who sell and install fans. Scores of contractors were visited and asked for suggestions for an ideal fan... one that would make the job of selling and installation easier and more profitable... one that would please the user, too. Out of the experience of these contractors came many constructive suggestions.

To these ideas, we added our own... the result of many years of experience in making this type of equipment. Then we put to work all our resources, and all the abilities of Sturtevant engineers. Our aim was to produce as nearly as possible the ideal propeller fan. Those who have seen the new Sturtevant say that we have succeeded. Certainly it is a notable improvement... decidedly better looking...exceptionally light and easy to install—highly efficient and quiet running.

The price is right, too. You can sell the new Sturtevant and meet "good fan" competition. Line-up with this fan, now, for a profitable business in commercial and industrial ventilation. The season is here. Mail the coupon... and get the facts about the New Sturtevant without delay.



B. F. STURTEVANT COMPANY
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Sturtevant REG. U. S. PAT. OFF.

Propeller Fan

B. F. STURTEVANT COMPANY, Hyde Park, Boston, Mass.
☐ Please send me Bulletin No. 385, containing all the facts about the New Sturtevant Propeller Fan.
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